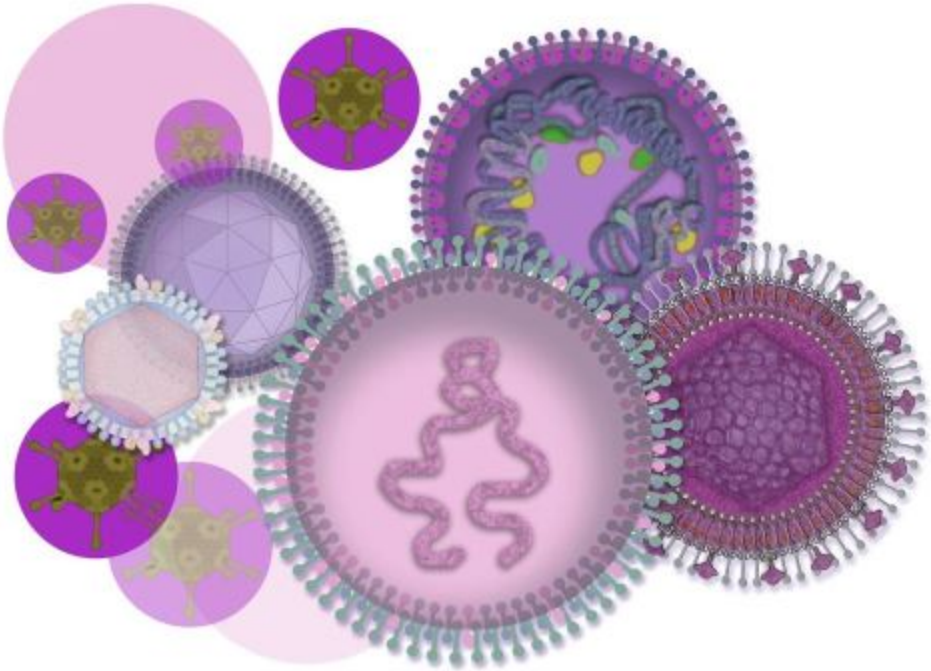

Virology
an Interactive Guide

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Virology: an Interactive Guide

User Guidelines

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- The work is under the protection of Creative Commons, which allows free use of the material for didactic purposes, as long as the work and the authors are credited and it is not used for commercial purposes.
- The ideal support for its reading is the computer screen, although it can also be read on a tablet or mobile phone. If the characteristics of the screen that you use are not suitable, we recommend that you modify them with the zoom.
- It is divided into sections that cover all the different aspects of Virology: basic virology, diagnosis in virology, emerging viruses, clinical virology, veterinary virology, plant viruses, food virology, virus of microorganisms and biotechnological applications of viruses.
- It is not necessary, although desirable, to have read the previous chapters before passing to the next one. Each section is identified by an icon on the top right hand corner of each chapter.
- It is practical and manageable. Basic general concepts are expressed clearly and concisely and are supported on figures, carefully elaborated by artists. It is fully updated.
- Each Chapter is presented in a single chart, at the top of which is an introduction on the basic aspects of the chapter. It is distributed in two or three panels, usually expandable to make them easier to read and provide the information logically and gradually, sometimes interconnected between them. When you're reading, search for the information "i" or those areas that light-up as you pass the cursor over them.
- On the left side there is a drop-down navigation menu, to quickly reach any chapter. To the right there is a comprehensive glossary with the most frequent terms of Virology.
- We are aware that there may be mistakes that have gone unnoticed. We hope we've minimized them and will appreciate feedback and corrections for future editions

Virology: an Interactive Guide

Index

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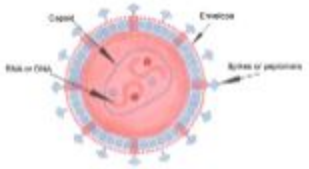
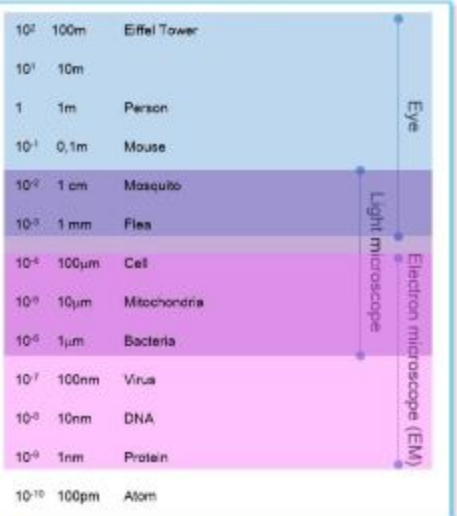
Section I: Basic Virology

Chapter 1 Introduction

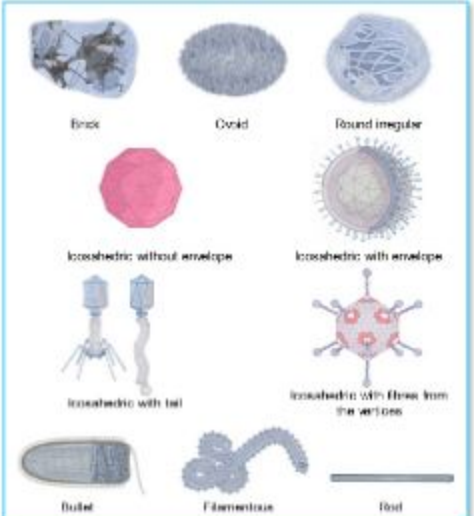


Viruses are very simple, formed only by nucleic acid (DNA or RNA, but not both), surrounded by protein, which protects it (capsid). Some viruses are also enclosed by a lipid bilayer (envelope), which originates from the cell they have infected, in which proteins codified by the viral genome are embedded.

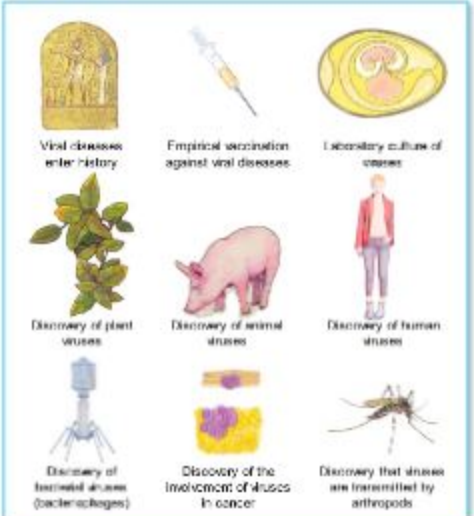
Size



Shape



History



Chapter 2 Composition of viruses

Virus particles (also called virions) are composed of:

- nucleic acid, either RNA or DNA but never both (the genome).
- different types of structural proteins: capsid proteins (naked viruses) ... [+info]

In addition, some viruses (called enveloped viruses) may have a lipid bilayer of host origin (the envelope).

Viral particle = virion

Viruses are either naked or enveloped. Naked viruses are composed only of nucleic acid, protected by a viral protein capsid, whereas enveloped viruses are surrounded by a lipid envelope.

Naked (non-enveloped) virus: different shapes possible
(for examples see chapter 1)

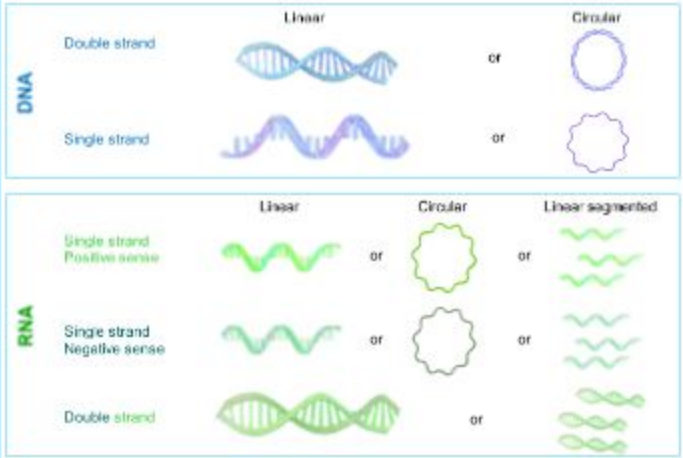
Viruses stable in the environment, enabling indirect transmission through inert materials (fomites)

Enveloped virus: different shapes possible (for examples see chapter 1).
Viral envelope comprises a lipid bilayer derived from any of the host membranes in which viral envelope proteins are anchored

Viruses fragile in the external environment preventing indirect transmission through inert supports

Types of nucleic acids

Viruses with RNA genome are more subject to mutations allowing sometimes for switching of host (see chapter 6)



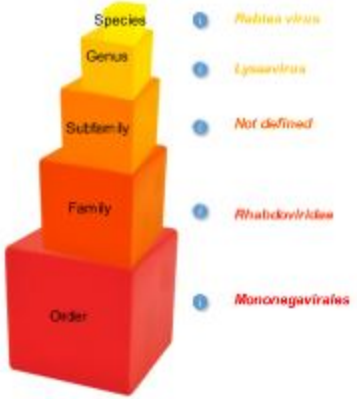
Chapter 3 Taxonomy of viruses

Taxonomy is the process of naming viruses and organizing them according to rational criteria. There are several ways of classifying viruses. The most generalized one uses phenotypic characteristics, such as type of nucleic acid, morphology, presence of envelope, mode of replication, host organisms and the type of disease they cause.

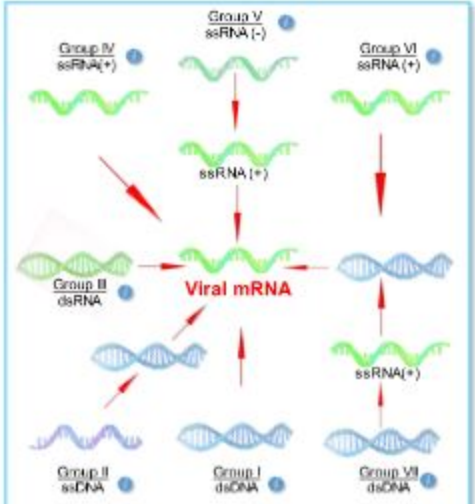
The two main schemes for classifying viruses are the system proposed by the International Committee on Taxonomy of Viruses (ICTV) and the system proposed by Baltimore, based on how viral mRNA is reached.

Official taxonomy of viruses

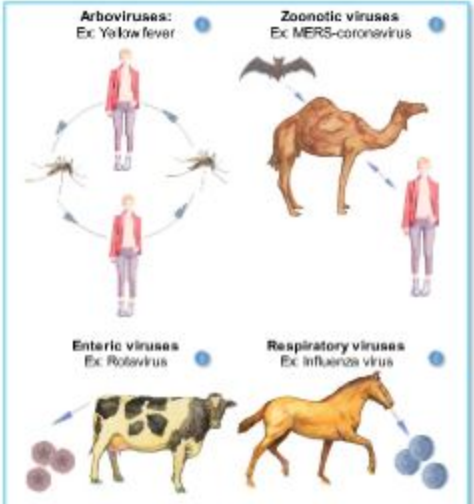
It is coordinated by the ICTV (International Committee on Taxonomy of Viruses) www.ictvonline.org This classification is based on a polythetic approach, grouping viruses according to different simultaneous properties such as virion morphology, viral genome, strategy of replication, etc.



Strategies of replication



Classification according to transmission



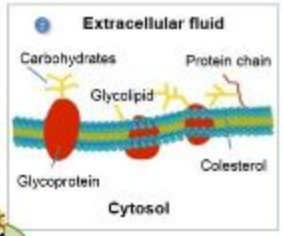
Chapter 4 Replication of viruses

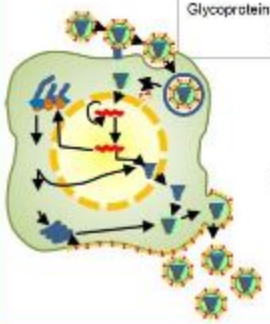
Viral replication is the formation of new viruses during the infection process in the target host cells. The first step is penetrating the cell, for which receptors usually play a fundamental role. Once inside the cell, many copies of the viral genome are formed (replication) and genes are transcribed into mRNA to form new proteins.

Structural proteins come together (assembly), including the nucleic acid inside and new viruses leave the cell to infect other cells. Most DNA viruses assemble in the nucleus while most RNA viruses develop solely in the cytoplasm.

The virus replication cycle

Basic steps of the virus replication cycle





Virus replication requires living cells – prokaryotic bacteria or eukaryotic plant and animal cells

What happens in the host cell?

Baltimore classification

Baltimore Group	Genome	Human/Animal viruses Examples	Nucleic Acid Replication	
			Method	Location
I	dsDNA	Herpesvirus, Poxvirus, Adenovirus	DNA → DNA	Nucleus
II	ssDNA	Parvovirus, Circovirus	DNA → DNA dsDNA intermediate	Nucleus
III	dsRNA	Reovirus, Rotavirus	RNA → RNA	Cytoplasm
IV	ssRNA(+)	Poliovirus, Rhinovirus Hepatitis A virus	(+)RNA → (-)RNA	Cytoplasm
V	ssRNA(-)	Influenza virus Rabies virus	RNA → RNA	Cytoplasm
VI	ssRNA / DNA intermediate	Retrovirus	RNA → DNA	Cytoplasm
VII	dsDNA / RNA intermediate	Hepatitis B virus	DNA → RNA then RNA → DNA	Nucleus Cytoplasm

Chapter 5 Culture of viruses

As viruses only have one type of nucleic acid, they can only replicate in living cells. They were first grown in animals, mostly mammals. Later, it was discovered that they could grow in chick embryos. Nowadays, viruses are mostly grown in cell cultures. Inoculation in experimental animals is still necessary to study viral pathogenesis or the immune response raised by them, and some viruses cannot grow in cell cultures.

In general, it is easier to grow viruses in cells which are not very differentiated.
When viruses replicate in cells, they may produce alterations evident with the microscope or even by the naked eye. This constitutes the cytopathic effect, which many times gives a clear indication of which virus is infecting the cell (pathognomonic).

Animal culture

Chicken embryo > duck embryo

Advantages

Disadvantages

Uses

Chorioallantoic cavity
Influenzavirus, mumps

Chorioallantoic membrane
Smallpox, herpesvirus

Amniotic cavity
Influenza

Yolk sac
Rabies, flavivirus

Technique

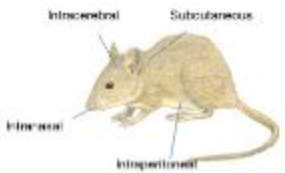
Signs of viral growth

Experimental animals

Advantages

Disadvantages

Uses



Cell culture

Requirements

Laminar flow hood | Plasticware | Culture medium | CO_2 incubator

Primary and secondary cultures

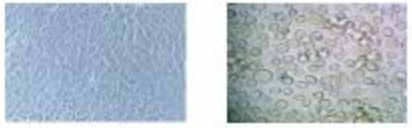
Example of technique for obtaining primary cultures

Cell lines

Advantages

Disadvantages

Uses

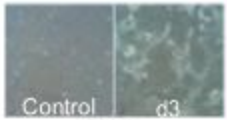


Adherent cultures | Suspension cultures

Cytopathic effect

Morphological changes observable in cells due to viral infection. However, many viral infections do not produce any visible cellular changes.

Inclusion bodies



Cell lysis

Syncytia formation

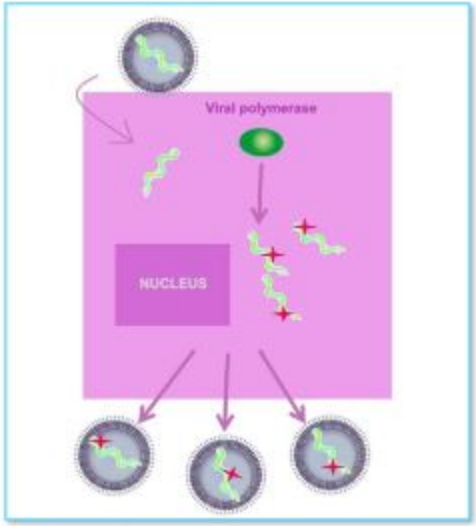
Apoptosis

Accelerated growth

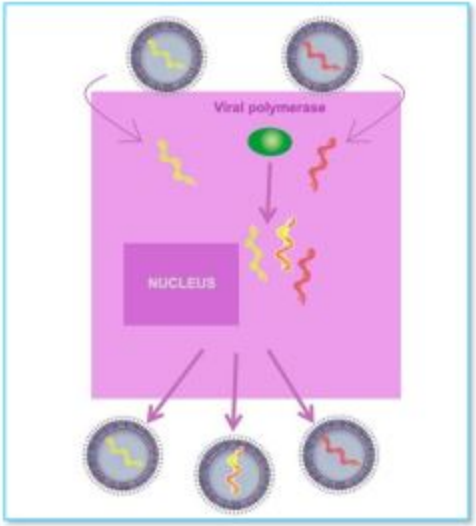
Cell enlargement

Viruses evolve through three main mechanisms: mutation, recombination and reassortment. All mechanisms may result in new viruses with new biological properties, such as new host range or pathogenic potential (see chapter 7).

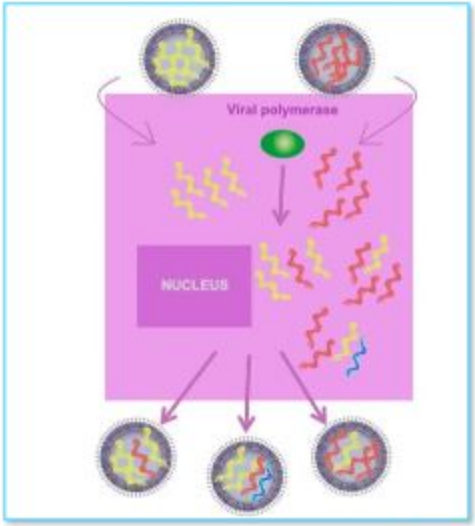
Mutation



Recombination



Reassortment



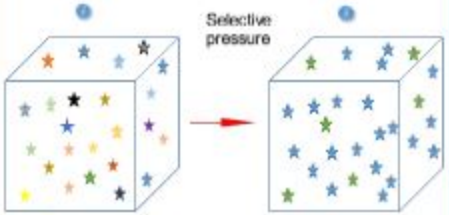
Chapter 7 Consequences of genetic modifications

Viral evolution is the result of genetic variation and selection of variants from a large viral population, usually on the basis of their fitness. Quasispecies are a group of viral variants found in RNA viruses, collectively responsible for pathogenesis and tissue distribution of viruses.

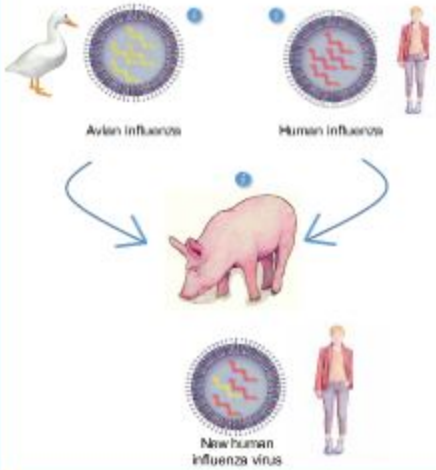
A consequence of variation and selection balance can be a change in tropism of the virus, or even the shifting of host. Such is the case of parvovirus due to the change in the viral proteins which bind the receptors in the host cells. Immune evasion is a major strategy adopted by many pathogenic viruses, such as influenza virus, HIV-1 and foot-and-mouth disease virus.

Viral quasispecies

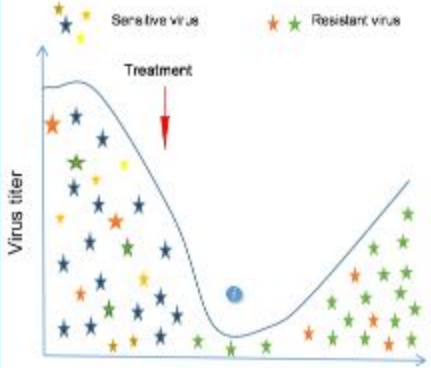
Mutations lead to the appertion of closely related viral populations, termed viral quasispecies. Mutant spectra are the source of virus adaptability to different contexts



Host switch (e.g.: Influenza)



Antiviral drug resistance

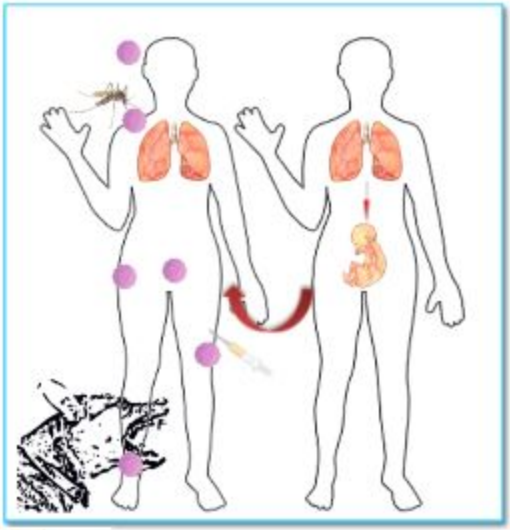


Chapter 8 Pathogenesis

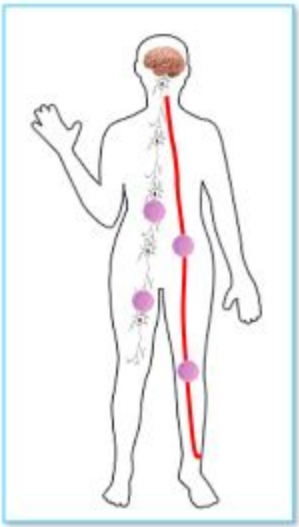
Pathogenesis is the process by which an infection leads to disease in the target host. Pathogenic mechanisms of viral disease include (1) entry of the virus, (2) local replication and spread to target organs (disease sites), (3) replication in the target organs, and (4) shedding of virus into the environment.

The result of the viral invasion depends both on the virus and on the host defences. Natural selection favours the dominance of low-virulence virus strains.

1. Transmission

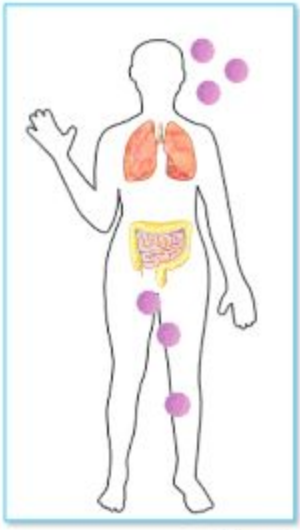


2. Dissemination



3. Localisations

4. Excretion



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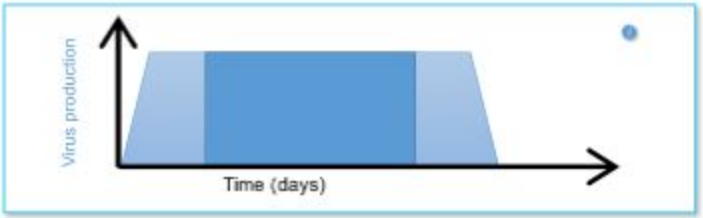
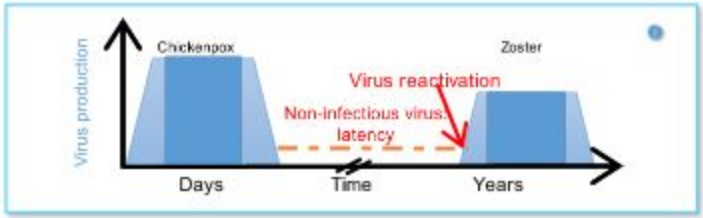
Chapter 9 Types of infection

In contrast to acute viral infections, persistent infections last for long periods, and occur when the primary infection is not cleared by the adaptive immune response.

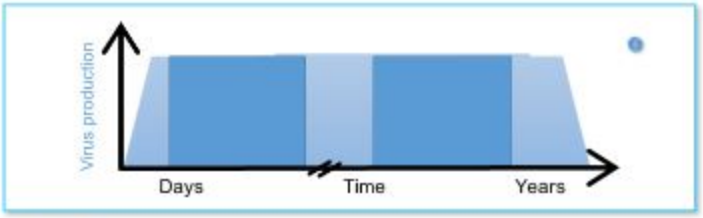
Acute infection (e.g. Influenza)



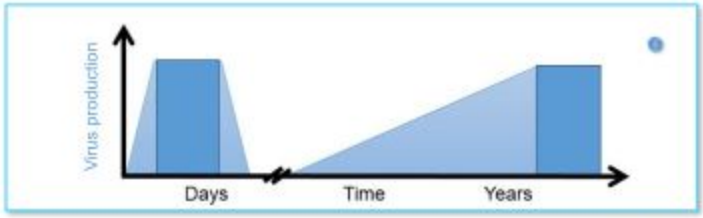
Latent infection (e.g. Chickenpox - Zoster)



Chronic infection (e.g. Hepatitis B)



Progressive infection (e.g. AIDS)

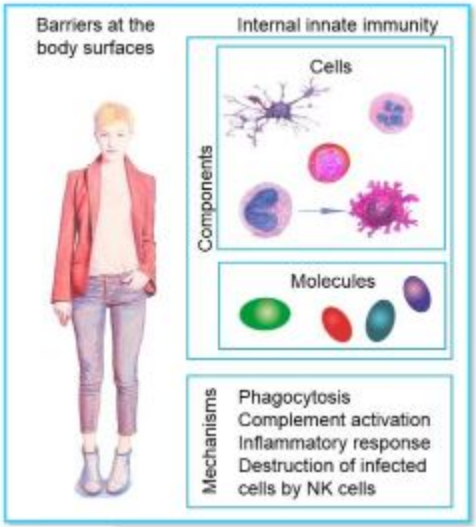


Chapter 10 Immune responses

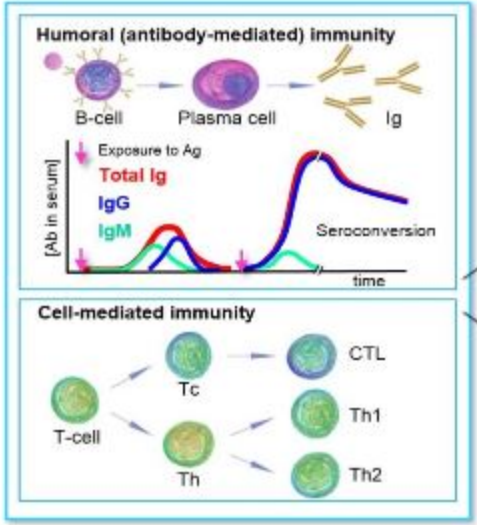
Vertebrates and many invertebrates count on innate immunity to defend themselves from pathogens. Innate immunity is the first line of defence against viruses and acts .. [+info]

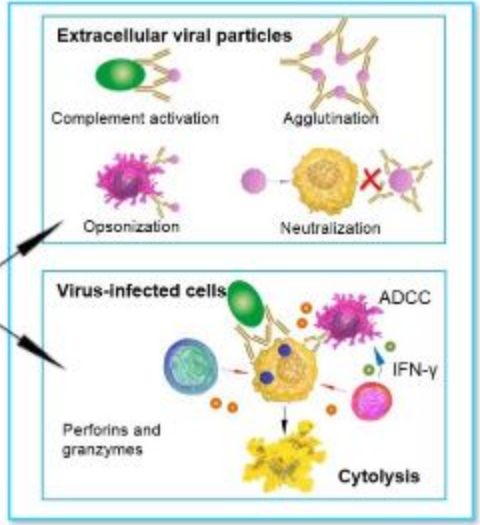
Adaptive immune response is only present in vertebrates, becoming more complex with evolution. Its main characteristics are specificity and diversity (being able to distinguish between small differences between numerous antigens), memory (stronger reaction in successive encounters with the antigen) and being self-limiting. It has two main branches: .. [+info]

Innate immunity



Adaptive immunity



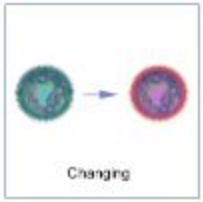


Chapter 11 Immune evasion and immune subversion

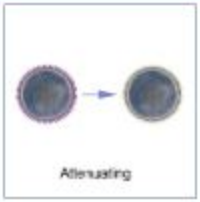
During millions of years viruses have coexisted with their hosts. Viruses have evolved numerous strategies to counteract and evade host's antiviral responses. Unravelling these viral strategies allows a better understanding of viral pathogenesis, and is important for identifying novel molecular targets for developing antiviral reagents and antiviral vaccines.

See Chapters 8, 10 and 12

Immune evasion

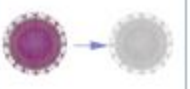


Changing



Attenuating

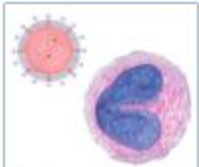
Hiding



Producing a smokescreen

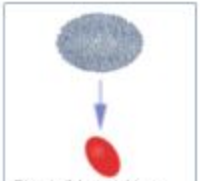
Turning host's defenses to own advantage

Immune subversion

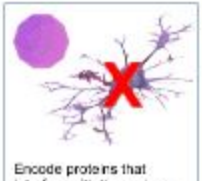


Replicate and/or persist in cells of the immune system

Induce the host to produce substances that are useful for the virus



Encode false cytokines and false cytokine-receptors



Encode proteins that interfere with the various defence molecular pathways

Chapter 12 Plant defences against viruses

Plant resistance is a genetically determined reduction or elimination of plant infection by a pathogen (virus); it is a reduced potential for the disease caused by that virus. The resistance that exists in plants before infections, based on e.g. morphological structures of plant cells and tissues, is called a pre-existing resistance.

The plant defence mechanisms evolving after infection include:

- Hypersensitivity - a rapid host cell death response associated with defence mediated by "resistance genes R" ...[+info]

Level of plant resistance to virus inoculation

Resistant variety

Moderately resistant variety

Moderately susceptible variety

Susceptible variety

Breeding for resistance

Chapter 13 Control of viruses

Viruses comprise enormously different pathogenic particles that infect humans, animals, plants and microorganisms, with vast variation in their epidemiology and pathogenesis.

Therefore, there is no universal approach to their control. Some preventative measures are routinely used to prevent and control viral diseases.

Sanitary practices

Vaccination

Quarantine

Vector/pest control

Proper way to wash hands

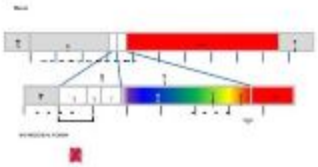
Sanitation/hygiene/cleaning

Physicochemical methods

Low pH

Thermal treatment: pasteurization, dry heat, vapour heat

Solvent/detergent



Irradiation with ultraviolet light (UV)

Gamma irradiation

Chapter 14 Vaccines

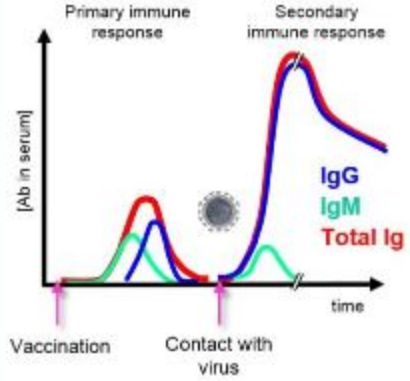
Vaccination or active immunization involves the administration of an antigen to the person or animal, so they respond effectively against it and develop a specific immune memory.

Subsequent exposure to the same virus will elicit a secondary response, faster and of greater intensity and duration than the primary immune response.

History of viral vaccines

	Year	Vaccines
XVIIIth century	1796	Variola
XIXth century	1885	Rabies
XXth century	1936	Yellow fever
	1945	Influenza
	1955	Polio
	1963	Measles
	1967	Mumps
	1969	Rubella
	1981	Hepatitis B
	1995	Chickenpox, Hepatitis A
	1998	Rotavirus
XXIth century	2006-2007	Papillomavirus

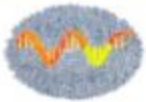
Principles of vaccination

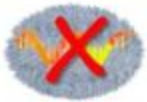


Types of vaccines


Live-attenuated


Inactivated


Replicative recombinant


Non-replicative recombinant


Sub-unit

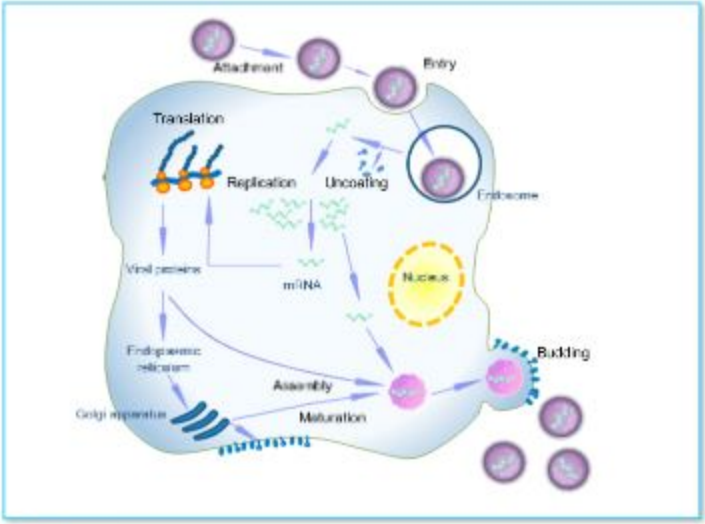

DNA

Chapter 15 Antivirals

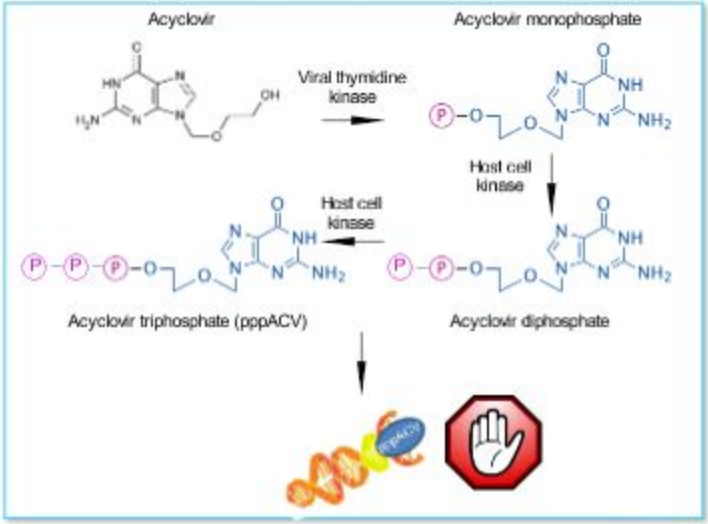
Unlike bacteria, ANTIBIOTICS ARE OF NO USE FOR TREATING VIRAL DISEASES. This is because it is really difficult to find pathways which may be affected without producing a deleterious effect on the host cell, as viruses are so similar to cell components. Drugs which are used specifically for treating viral infections are called antivirals.

Unlike most antibiotics, antiviral drugs do not destroy their target pathogen, but rather inhibit their development. Most of the antiviral drugs used are effective against a very limited number of viruses, and need to be administered early in infection.

Antiviral drugs block various stages of viral replication

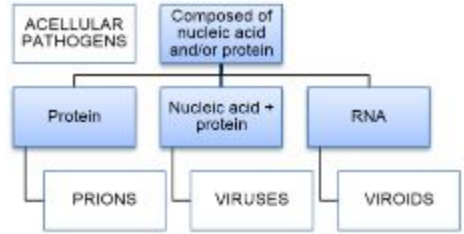


Mechanism of action of acyclovir

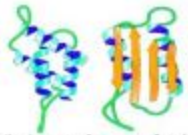


Chapter 16 Prions and viroids

There are infectious agents even smaller than viruses!! These include prions, which are just protein, with no identifiable nucleic acid, and viroids, only short sequences of RNA. Some prions produce zoonotic diseases. Such is the case of ...[+ info]



What are prions?



Schematic images of a normally shaped protein (left) and its infectious prion form (right)

Foodborne prions

Classification of prion diseases

Routes of transmission

BSE in Europe

BSE and vCJD: potential exposure through international trade

What are viroids?

Classification of viroids

- Family *Pospiviroidae* (nuclear viroids)
- Family *Avsunviroidae* (chloroplastic viroids)

Apple scar skin viroid (ASSVd)

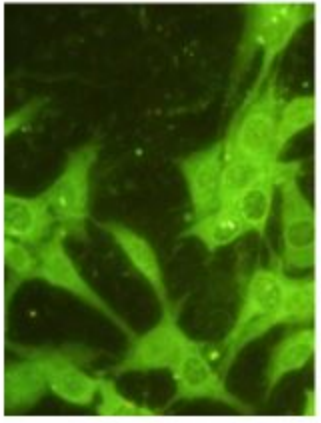
Hop stunt viroid (HSVd)

Coconut cadang-cadang viroid (CCCVd)

Chrysanthemum stunt viroid (CSVd)

Potato spindle tuber viroid (PSTVd)

Section II: Diagnosis in Virology



Chapter 17: Virological methods

Chapter 18: Serological diagnosis

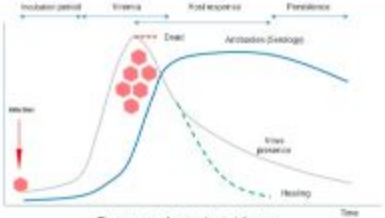
Chapter 19: Nucleic acid amplification

Chapter 17 Virological methods

Diagnosis may be either direct (detecting the virus itself, viral antigens or its nucleic acid), or indirect (detecting antibodies against it). The specimen used for direct detection and virus isolation is very important. A positive result from the site of disease has ...[+info]

During a viral infection, specimens for virus detection can be obtained from tissues and target organs where the virus replicates (disease sites), or from the routes it uses for spreading (e.g., blood). It is critical that the collected specimen is representative of ...[+info]

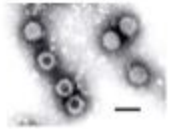
Sampling



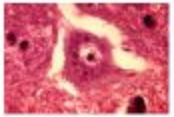
Time course of an acute viral disease

Some common methods

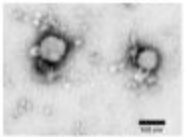
Electron Microscopy (EM)



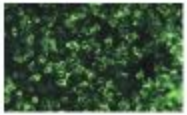
Detection of morphological changes in cells by Light Microscopy



Immune Electron Microscopy (IEM)



Detection of viral antigens: Immunofluorescence



Virus isolation: Culture (Chapter 5)

Lysis

Vacuolization

Accelerated growth

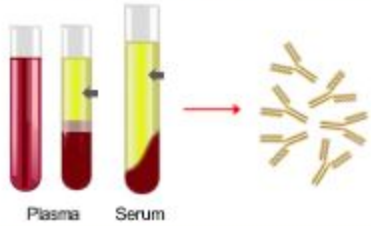
Chapter 18 Serological diagnosis

Viral infection can be diagnosed using immunological assays, which can detect either viral antigen ("direct diagnosis") or specific antibodies against the virus ("indirect diagnosis") in samples. Immunological assays must be highly specific and sensitive to avoid false results.

The indirect diagnosis is also called "Serological Diagnosis" or "Serology" because it is mainly performed with serum samples. It is based on the ability of an antibody to react with a specific antigen forming an immune complex that can be detected "in vitro".

Samples and interpretation

Samples used in serological diagnosis

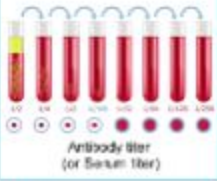


Interpretation of serological diagnosis

- Serology results depend on the type of viral infection
- Viral serology is useful for clinical virology
- Some problems with serological diagnosis

Types of serological tests

Quantitative



Conjugate-based assays

Qualitative

Biological assays

Specificity and sensitivity of a serological test

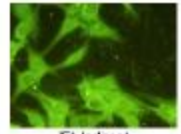
Most used techniques in viral serology

1. Assays performed in the laboratory

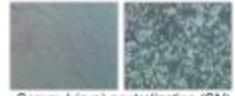
Enzyme immunoassays (EIA)

ELISA

Western blot



IFI Indirect Immunofluorescence



Serum (virus) neutralization (SN)

Inhibition of hemagglutination (HIA)

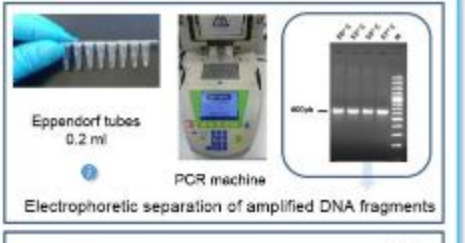
2. Disposable immunoassay devices

Chapter 19 Nucleic acid amplification

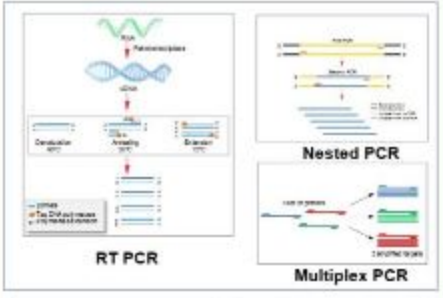
Molecular techniques have experienced a rapid development during the last 30 years and they are currently considered reference methods in the clinical laboratory. The main advantages of molecular diagnostic techniques are their high sensitivity and reproducibility.

The PCR is a simple chemical reaction that permits the synthesis of millions of copies of the targeted sequence through the action of a thermostable DNA polymerase, originally isolated from *Thermus aquaticus*, which can copy a DNA strand using another DNA as … [+ info]

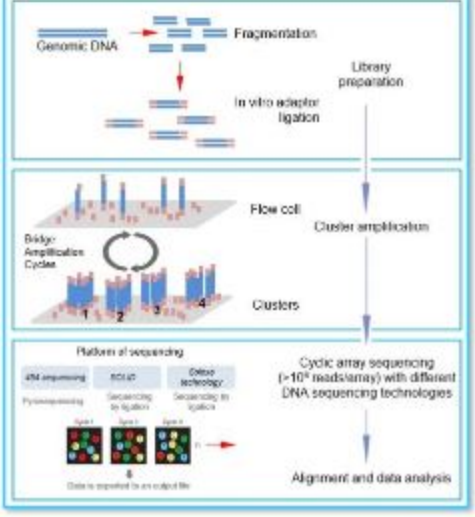
PCR (Polymerase chain reaction)



Variants of PCR



NGS: Next generation sequencing



Section III: Emerging viral diseases

Chapter 20: Influenzavirus

Chapter 21: Ebolavirus

Chapter 22: Dengue

Chapter 23: MERS Coronavirus

Chapter 24: Lassa Fever

Chapter 25: Chikungunya

Chapter 26: Crimean-Congo Haemorrhagic Fever (CCHF)

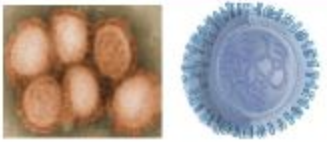
Chapter 20 Influenzavirus

Influenza viruses circulate and cause disease in humans every year. In temperate climates, disease tends to occur seasonally in the winter months, spreading from person-to-person through sneezing, coughing, or touching contaminated surfaces. Seasonal influenza viruses can cause mild to severe illness and even death, particularly in some high-risk individuals.

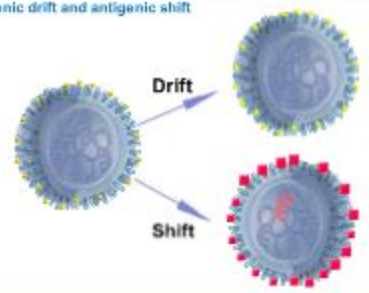
The viruses evolve continuously, which means that people can get infected multiple times throughout their lives. Therefore the components of seasonal influenza vaccines are reviewed frequently (currently biannually) and updated periodically to ensure continued effectiveness of the vaccines ... [+ info]

The virus and variability

The virus

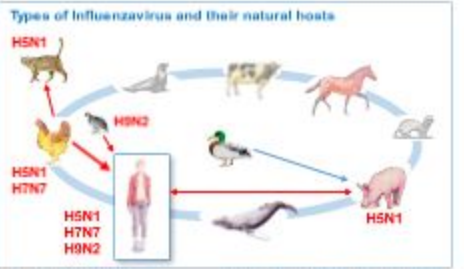


Antigenic drift and antigenic shift



Epidemiology and zoonotic potential

Types of Influenzavirus and their natural hosts



Emergence of 2009 pandemic influenza

Global distribution of influenzavirus A (H5N1)

Symptoms and control

Clinical symptoms

Seasonal influenza A vaccine strategy

Erasmus+

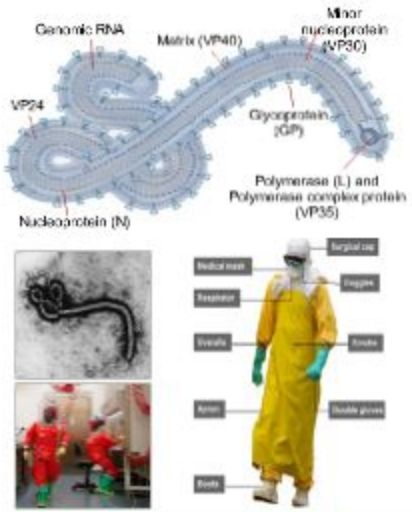
< PREV NEXT >

Chapter 21 Ebolavirus

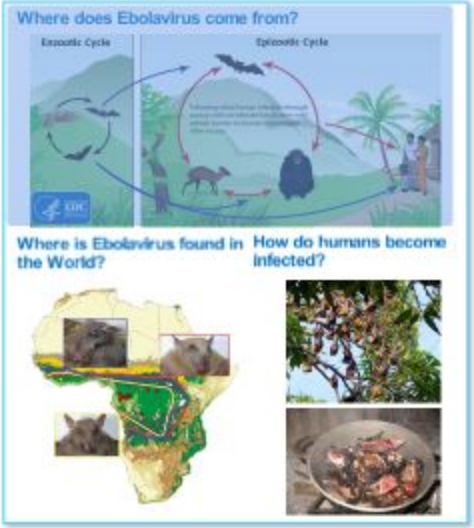
Ebola was first identified in June 1976. There are five distinct Ebolavirus strains, all with differing levels of mortality to someone that is infected. In the two years spanning December 2013 to December 2015, an outbreak of Ebolavirus (Zaire strain) infected over 28,000 people in Guinea, Sierra Leone and Liberia, killing over 11,000 of those infected.

Given the high transmissibility of the virus from those infected and from those that died, the virus was able to spread rapidly and even made its way into other countries around the world when infected individuals including several frontline health workers that returned to their home countries.

The virus and its handling



Epidemiology



Symptoms and prevention

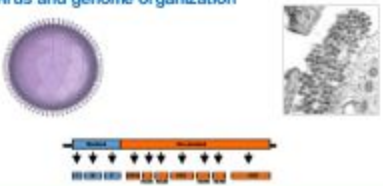
Chapter 22 Dengue

Dengue virus is spread through *Aedes* mosquito bites. It is a risk to anyone living in or traveling to a tropical or subtropical region of the world where *Aedes* mosquitoes are found. No vaccine currently exists for Dengue (although a Mexican vaccine is now in phase III clinical trials). Effective preventative measures do exist, namely the reducing exposure to infected mosquitoes.

Approximately 1 in 4 people infected with dengue will develop symptoms; in some cases a more severe form of Dengue fever illness can present called Dengue Haemorrhagic Fever (DHF) which can be fatal. Globally, there are an estimated 50 to 100 million cases of dengue fever (DF) and several hundred thousand cases of dengue haemorrhagic fever (DHF) per year.

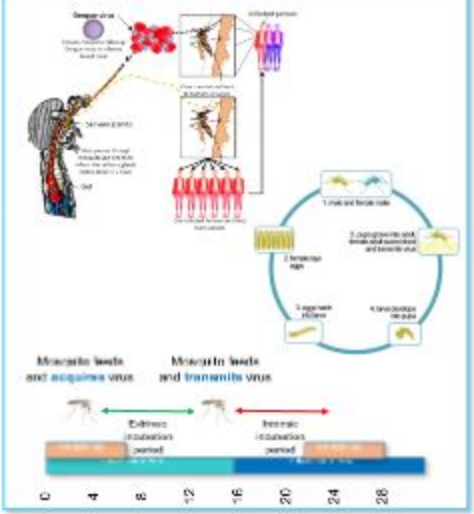
Dengue virus (DENV) and control

The virus and genome organization



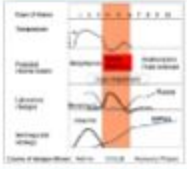
Preventing infection - mosquito control

Role of the mosquito *Aedes*

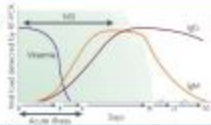


Distribution, symptoms and diagnosis

Where is DENV found in the World



Detection of DENV Which assay? When?



Erasmus+

Chapter 23 MERS Coronavirus

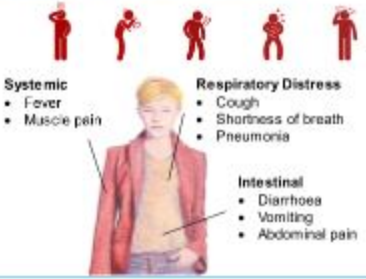
Middle East Respiratory Syndrome (MERS) is a viral respiratory illness that is new to humans. It was first reported in Saudi Arabia in 2012. The virus that causes MERS is called Middle East Respiratory Syndrome Coronavirus (MERS-CoV). Coronaviruses are common viruses that most people get some time in their life. Human coronaviruses usually ... [+ Info]

MERS-CoV likely came from an animal source in the Arabian Peninsula. Researchers have found MERS-CoV in camels from several countries. We don't know whether camels are the source of the virus. Studies continue to provide evidence that camel infections may play a role in human infection with MERS-CoV. However, more information is needed.

The virus and clinical symptoms

The virus (MERS-CoV)

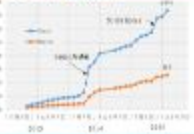
Clinical symptoms of MERS-CoV Infection



Epidemiology and control

Geographical distribution of laboratory confirmed cases

Number of cases by year



Measures to prevent person to person transmission

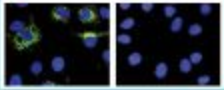
Transmission of MERS-CoV

Indirect infection with MERS-CoV

The role of camels in MERS-CoV Infection

Laboratory detection of MERS-CoV

RT-PCR Targets
- UpE (E gene)
- ORF1a
- Nucleocapsid



Chapter 24 Lassa fever

Lassa fever is an acute viral haemorrhagic illness of 1-4 weeks duration that occurs in West Africa. The Lassa virus is transmitted to humans via contact with food or household items contaminated with rodent urine or faeces.

Person-to-person infections and laboratory transmission can also occur, particularly in hospitals lacking adequate prevention and control measures.

Lassa fever virus (LASV) and control

The virus

Preventing infection - rodent control

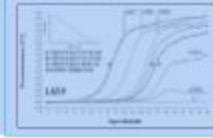
Clinical symptoms

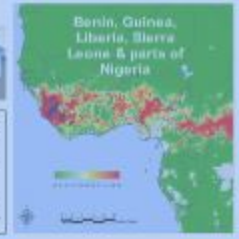
Clinical Symptoms Week 1 (80%)	Clinical Symptoms Week 2 (20%)
Fever and shivering	Temperature increase up to 41°C
Headache and Malaise	Extreme lethargy and exhaustion
Sore throat with patches of white or ulcers on the tonsils and/or pharynx	Oedema of the head and neck. Encephalopathy, pleural effusion
Nausea, vomiting and diarrhoea in some cases	Renal and circulatory failure, bleeding and death

Treatment and diagnosis

Treatment

Diagnosis





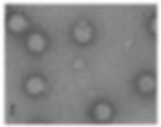
Chapter 25 Chikungunya

Chikungunya virus is an arthropod-borne virus (arbovirus) from the *Togaviridae* family of viruses. It belongs to the *Alphavirus* genus. Arboviruses are spread by mosquitos and other arthropods.

First recognized in Tanzania in 1953 during an outbreak of a Dengue-like illness, it gets its name from the African dialect of Swahili (Makonde) "Chikungunya" which means "that which bends up" which refers to the severe joint pain (arthralgia) experienced by patients.

The virus and distribution

The virus (CHIKV)



Global distribution

The disease

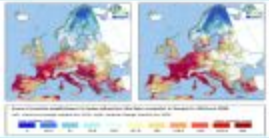
Clinical symptoms of Chikungunya fever

Diagnosis of Chikungunya fever in the lab

Period between start date of clinical symptoms and sample date	Laboratory test to be performed
< 5 days	Real-time RT PCR
Between 5 days and 7 days	Real-time RT-PCR & serology
> 7days	Serology

Role of mosquitoes in virus spread

Aedes albopictus may establish in new environments



Chapter 26 Crimean-Congo Haemorrhagic Fever (CCHF)

First described in Crimea in 1944 and later also found to be an illness observed in the Congo in 1956, Crimean Congo Haemorrhagic Fever virus (CCHFV) gets its name from these locations and the type of disease it causes.

CCHF is widely dispersed throughout Central Asia, Africa and Europe. The virus is transmitted to humans via the bite of ixodid ticks (*Hyalomma* species) or through contact with infected blood and tissues from infected livestock. Human to human transmission is also known to occur.

The virus and distribution

The virus (CCHFV)

Global distribution

Transmission

Infection from ticks

The disease (CCHF)

Crimean Congo Haemorrhagic Fever incubation time

Symptoms and treatment

Primary Symptoms (1-3 days)	Fever, muscle ache, neck pain, headache, sore eyes, photophobia
Secondary Symptoms (2-4 days later)	Drowsiness, depression, petechial rash on internal mucosal surfaces and on the skin
Severe symptoms (5 days onwards)	Rapid kidney deterioration, sudden liver or pulmonary failure
Mortality rate	~30% typically in second week

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Section IV: Clinical Virology

Chapter 27: Viral families that affect humans (and animals)

Chapter 28: Viruses and human cancer

Chapter 29: Viruses and human disorders

Chapter 30: Clinical virology

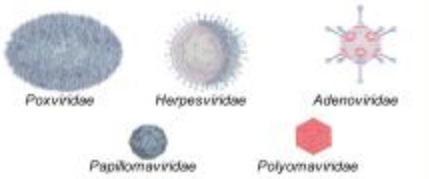
Chapter 31: Viral diseases in the immunocompromised host

Chapter 27 Viral families that affect humans (and animals)

One third of virus infections of humans is due to DNA viruses and two thirds to RNA viruses. A few diseases are caused by subviral agents. The viral families that may cause human diseases are:

DNA viruses

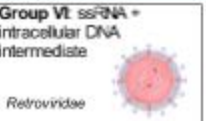
Group I: double-stranded DNA (dsDNA)



Group II: single-stranded DNA (ssDNA)

Reverse transcribing viruses

Group VI: ssRNA + intracellular DNA intermediate



Group VII: dsDNA + intracellular RNA intermediate

RNA viruses

Group III: double-stranded RNA (dsRNA)

Group IV: positive-sense single-stranded RNA (ssRNA+)

Group V: negative-sense single-stranded RNA

Subviral agents

Satellites (need co-infection with a helper virus) for productive multiplication

Infectious particles made only of protein

Prions

Chapter 28 Viruses and human cancer

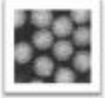
Around 11% of human cancers have a causal relationship with an oncogenic virus. The majority of these viruses have DNA for genome, but also RNA viruses can be oncogenic for humans.
Virus presence in a tumour does not mean causality, and causality does not necessarily require virus presence, since cancer is a multi-step process, and hit and run mechanisms may occur.

The majority of persons infected by oncogenic viruses stay asymptomatic or paucisymptomatic. Only in a small percentage of cases, in general after decades and with the contribution of multiple factors, a cancer may arise.
Place the cursor on the center of the photos to see more information

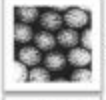
DNA tumour viruses

Epstein Barr virus (EBV), a γ-herpesvirus

Human Herpesvirus-8 (HHV-8), or Kaposi sarcoma Herpesvirus (KSHV), a γ-herpesvirus



Human Papillomaviruses (HPV)



Merkel Cell Polyomavirus (MCV) and other human Polyomaviruses

Human Hepatitis B virus (HBV), an Hepadnavirus

RNA tumour viruses

Human T-Lymphotropic Virus type I (HTLV-I), a δ-retrovirus

Human Hepatitis C virus (HCV), a hepacivirus in the *Flaviviridae* family

indirectly, also:

Human Immunodeficiency virus (HIV), a lentivirus of the *Orthoretrovirinae* subfamily

Chapter 29 Viruses and human disorders

Virus infections usually stimulate immune responses, generally in favour of the host.
Occasionally, something goes wrong, turning host reactions against self, leading to autoimmunity.

Some virus infections may induce autoimmunity, or activate latent/ autoimmune diseases, or worsen already established autoimmune diseases.
Other virus infections, instead, may cause partial or generalized immune suppression.

Autoimmunity

Virus infections, particularly persistent infections, may induce autoreactive T cells, autoantibodies, and/or production of pro-inflammatory cytokines.

Mechanisms:

- Molecular mimicry
- Epitope spreading
- Bystander activation
- Cryptic antigens

•Examples:

- Myocarditis after infection by Coxsackievirus B
- Herpetic stromal keratitis, after corneal infection by herpes simplex virus (can lead to blindness)
- Juvenile Type I diabetes after infection by Coxsackievirus B
- Multiple sclerosis (complex contribution of genetics, Epstein Barr virus and HERV-W endogenous retrovirus)
- Arthritis after infection by rubella in adulthood (the virus infects the joints, where it persists within synoviocytes).

Immune suppression

Some virus infections may cause partial or global immune suppression.

Mechanisms:

- Induction of tolerance: the host is induced to consider that specific virus as self. This occurs often during pregnancy
- Perturbation of immune response caused by secreted viral proteins
- Virus infection, killing and consequent depletion of immune cells

•Examples:

- Rubella infection during pregnancy causes specific tolerance and abnormal embryo development
- Measles may cause a transient, but severe immunosuppression in patients, which may allow secondary opportunistic infections by viruses and bacteria, largely responsible for measles-related morbidity and mortality in children of low-income countries
- HIV infects preferentially CD4⁺ cells (T-helper and T-effector lymphocytes, monocytes/macrophages and dendritic cells), that are essential for immune defence

Chapter 30 Clinical virology

Viral affinity for specific body tissues (tropism) is determined by different factors. Some of them are related to the cell itself. These include (1) cell receptors for virus, (2) cell transcription factors that recognize viral promoters and enhancer sequences, and (3) ability of the cell to support virus replication.

Other factors are related to physicochemical properties, such as physical barriers, local temperature, pH, and oxygen tension, enzymes and non-specific factors in body secretions, and digestive enzymes and bile in the gastrointestinal tract, that may inactivate some viruses.

Viral diseases at the body sites

Respiratory tract

Respiratory viruses that cause localized infections
Respiratory viruses that cause systemic disease
Common cold
Acute pharyngitis

Nervous system

Main viral diseases of the nervous system

Cardio-circulatory system

Heart
Blood vessels

Enteric tract

Main viral infections of the enteric tract:
Mouth
Intestine
Salivary glands
Rectum
Pancreas

Hepatitis

Major hepatitis viruses
Minor hepatitis viruses
Occasional hepatitis viruses

Lymphoid and hemopoietic system

Human viruses which persist in this system

Foetal and perinatal infections

Most common viruses transmitted vertically:
Antenatal infections
Perinatal infections

Skin and mucosa

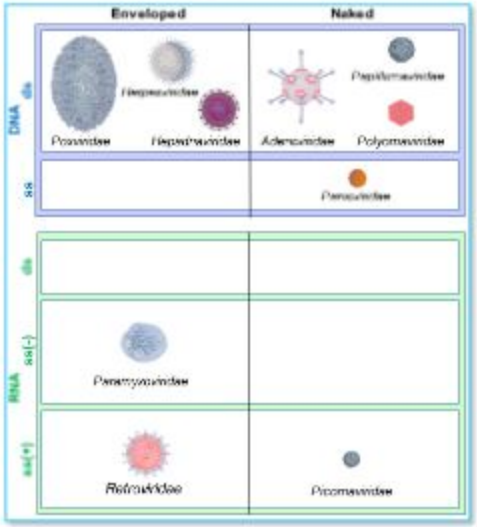
Main viral infections of the skin and mucosa
Localized infections
Systemic infections
Other viral syndromes

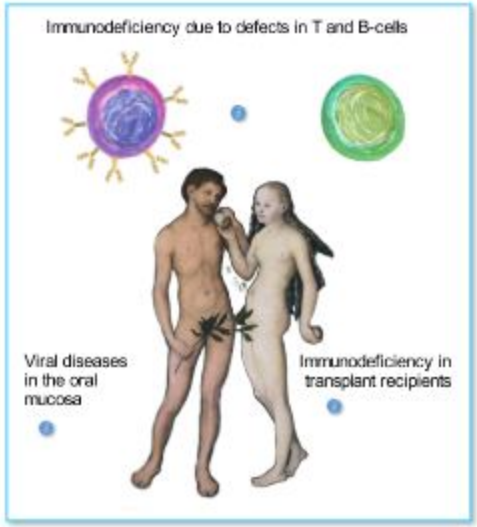
Chapter 31 Viral diseases in the immunocompromised host

When the immune system is weakened or impaired, the risk of becoming infected by viruses is increased, and there is a reduced capability to counteract the exogenous and endogenous virus infections.

Therefore viruses may add major complications to diseases causing relevant immune defects, such as acquired (AIDS) and congenital immunodeficiency, transplantation, cancer, etc., as well as to malnutrition, chronic diseases, as diabetes and asthma, and to the elderly.

Viruses frequently identified





Some viral diseases

Involvement of cytomegalovirus in immunodeficiency

Diseases produced by cytomegalovirus in transplant recipients

- Cytomegalovirus syndrome
- Cytomegalovirus-associated end-organ disease
- Indirect effects

Viral diseases in different locations in immunocompromised hosts

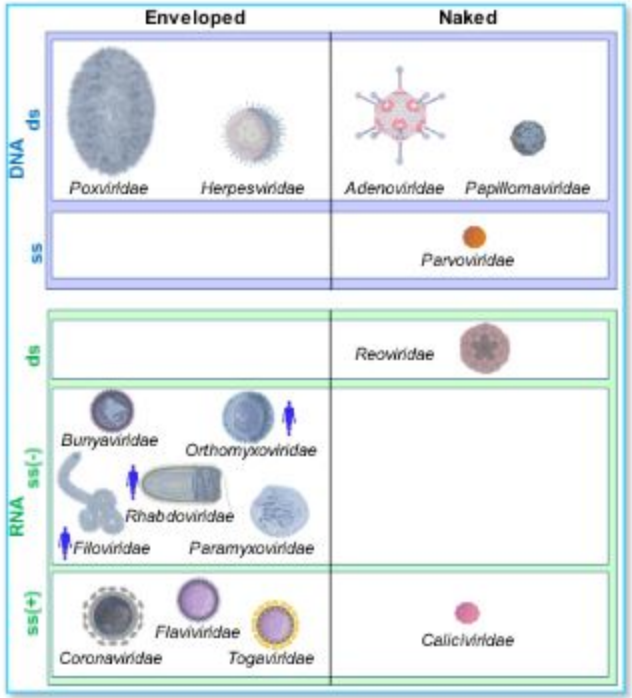
Section V: Animal viruses

Chapter 32 Virus diseases in dogs

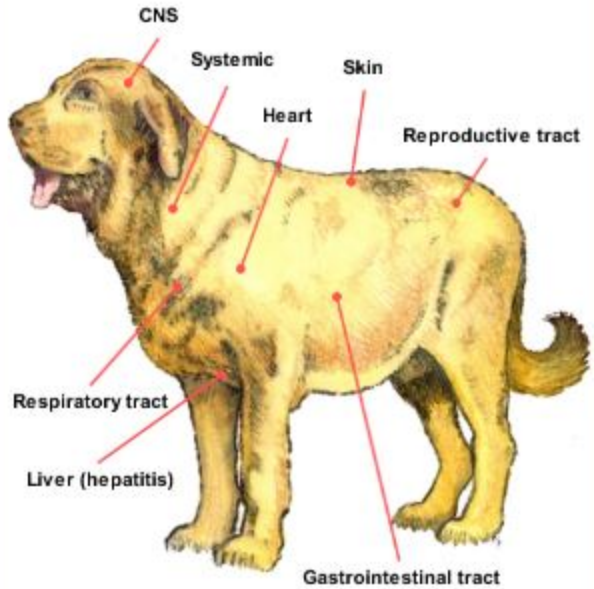
Dogs represent an important pet for humans and therefore, viral diseases affecting them may have a great impact, both for their possible zoonotic consequences and their human sentimental value. There are 15 family of viruses that may affect dogs, but fortunately not all have clinical relevance.

Knowing about common dog viral diseases and their appropriate prevention, can help to provide a proper health care.

Which virus affect dogs?



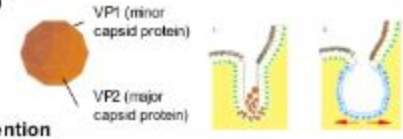
Viral diseases in dogs and severity



Some viral diseases

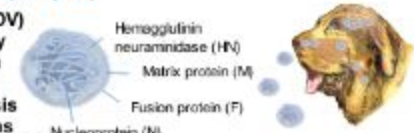
Canine Parvovirus (CP)

1. The virus (CPV)
2. Epidemiology
3. Transmission
4. The disease
   - Pathogenesis
   - Clinical signs
   - Medical Prevention



Canine Distemper (CD)

1. The virus (CDV)
2. Epidemiology
3. Transmission
4. The disease
   - Pathogenesis
   - Clinical signs
   - Medical Prevention



Canine Rabies

1. The virus (RV)
2. Epidemiology
3. Transmission
4. The disease
   - Pathogenesis
   - Clinical signs
   - Medical Prevention

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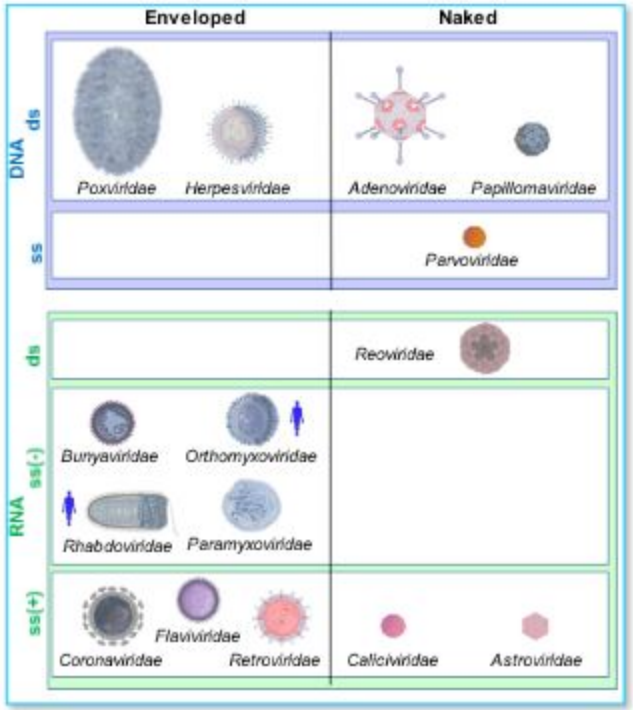
Chapter 33 Virus diseases in cats

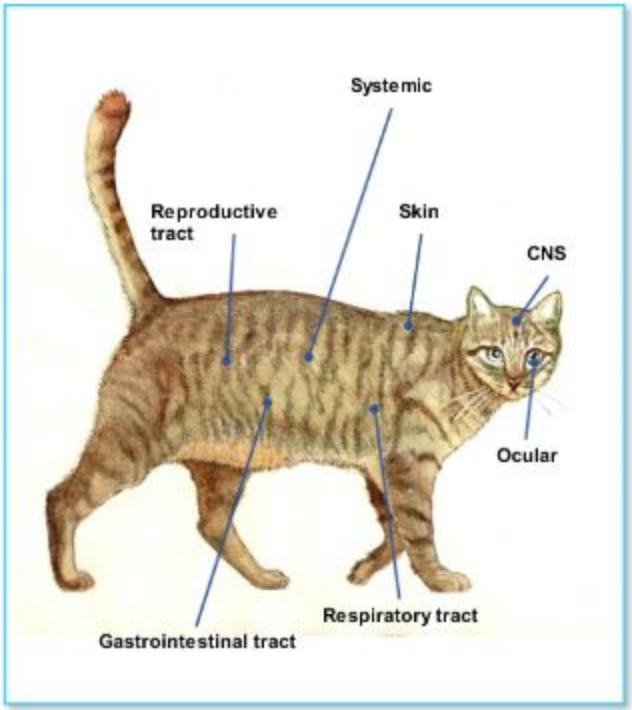
The cat has been living close to man some 9,500 years, and it is one of the most popular pets worldwide. Approximately 25 species of virus may affect cats. Commonly, feline viruses suppress the immune system or cause alteration of two or more organs or tissues, and are highly contagious amongst cats.

Most feline viruses infect only cats. However, rabies virus can be passed from cats to humans.

Which virus affect cats?



Viral diseases in cats and severity



Some viral diseases

Feline leukaemia (FeL)

1. The virus (FeLV)
2. Epidemiology
3. Transmission
4. The disease
   - Pathogenesis
   - Clinical signs
   - Medical Prevention

Feline panleukopenia (FPL)

1. The virus (FLPV)
2. Epidemiology
3. Transmission
4. The disease
   - Pathogenesis
   - Clinical signs
   - Medical Prevention

Feline infectious peritonitis (FIP)

1. The virus (FIPV)
2. Epidemiology
3. Transmission
4. The disease
   - Pathogenesis
   - Clinical signs
   - Medical Prevention

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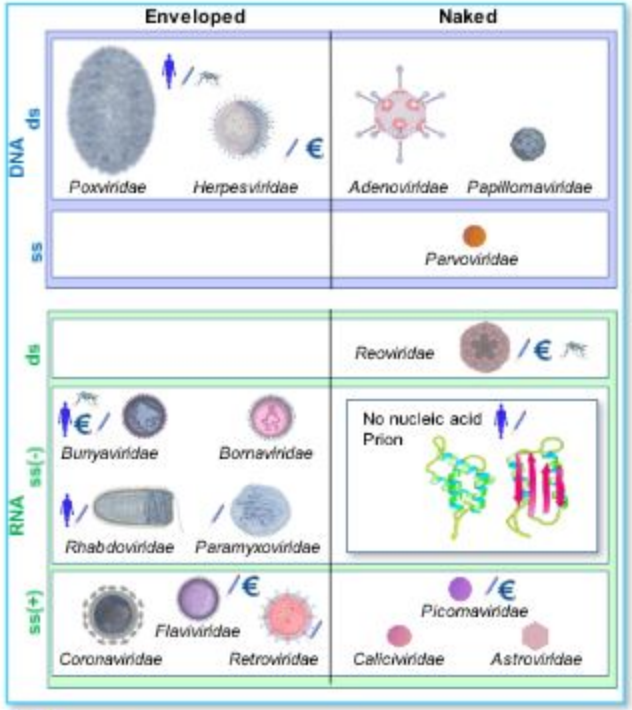
Chapter 34 Virus diseases in cattle

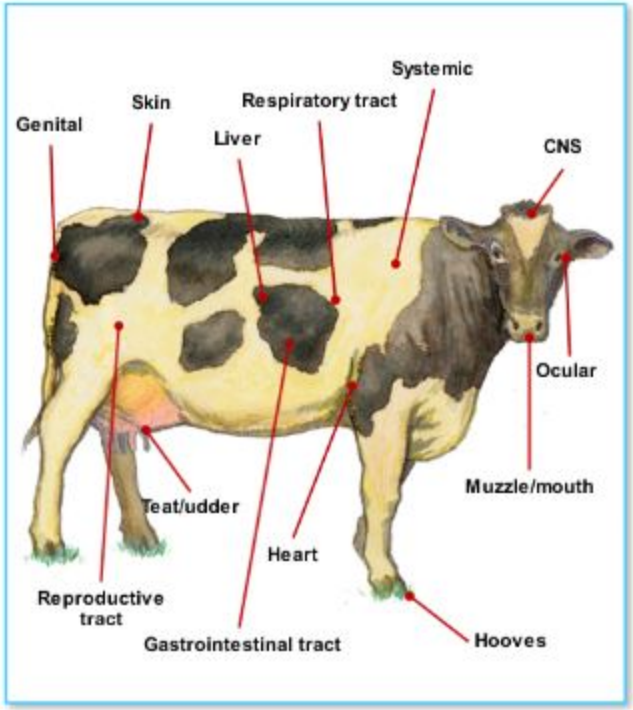
Many viruses cause diseases in cattle, and sometimes in other domestic and wild ruminants. Some diseases have been known for several centuries. Others, mainly those transmitted by arthropods, are emergent viral diseases. Most bovine viral infections are ...[+info]

Some bovine viruses are very important in history of Virology. Rinderpest (cattle plague) is the second viral disease eradicated from the globe after human smallpox. It was the oldest known and most devastating disease of cattle. The first Veterinary School ...[+info]

Which virus affect cattle?



Viral diseases in cattle and severity



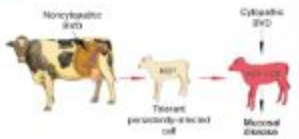
Some viral diseases

Infectious bovine rhinotracheitis (IBR)

1. The virus (BoHV-1)
2. Epidemiology
3. Transmission
4. The disease
   - Pathogenesis
   - Clinical signs
   - Medical Prevention

Bovine viral diarrhoea (BVD)

1. The virus (BVDV)
2. Epidemiology
3. Transmission
4. The disease
   - Pathogenesis
   - Clinical signs
   - Medical Prevention



Foot and mouth disease (FMD)

1. The virus (FMDV)
2. Epidemiology
3. Transmission
4. The disease
   - Pathogenesis
   - Clinical signs
   - Medical Prevention

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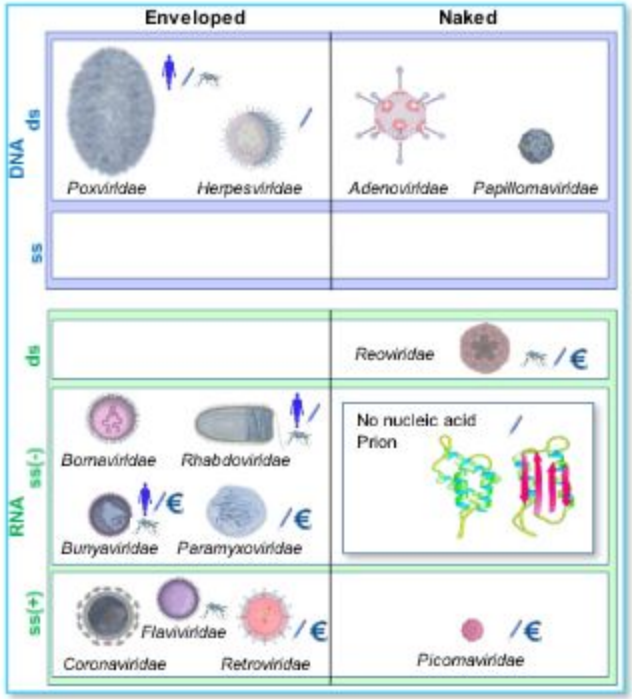
Chapter 35 Virus diseases in small rumiants

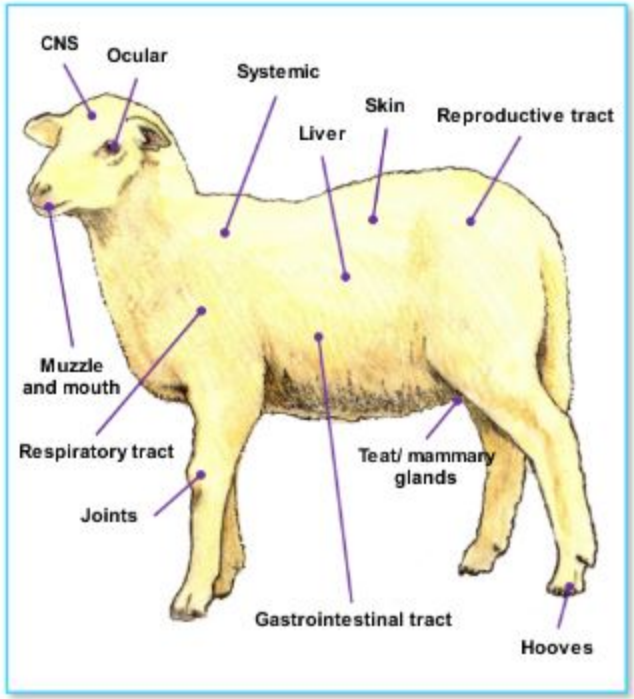
Sheep and goats are two different animal species, but are grouped together as "small ruminants". They are affected by similar viruses and share a lot of diseases, although sometimes with different consequences. Besides, some viruses can ...[+info]

Peste des Petit Ruminants (closely related to bovine rindespest) is a damaging disease with a rapid expansion in Africa, Middle East and parts of Asia, which threatens sheep and goats industry in these regions. Due to its importance ...[+info]

Which virus affect small ruminants?



Viral diseases and severity



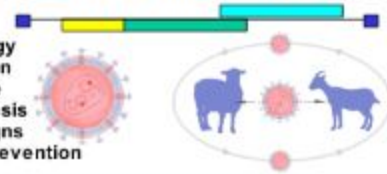
Some viral diseases

Bluetongue

1. The virus (BTV)
2. Epidemiology
3. Transmission
4. The disease
   - Pathogenesis
   - Clinical signs
   - Medical Prevention

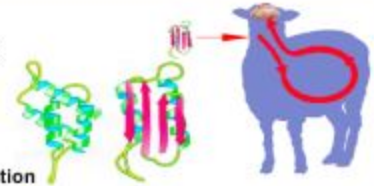
Maedi-Visna and Caprine Arthritis Encephalitis

1. The virus
2. Epidemiology
3. Transmission
4. The disease
   - Pathogenesis
   - Clinical signs
   - Medical Prevention



Scrapie

1. The agent (PrP^{Sc})
2. Epidemiology
3. Transmission
4. The disease
   - Pathogenesis
   - Clinical signs
   - Medical Prevention



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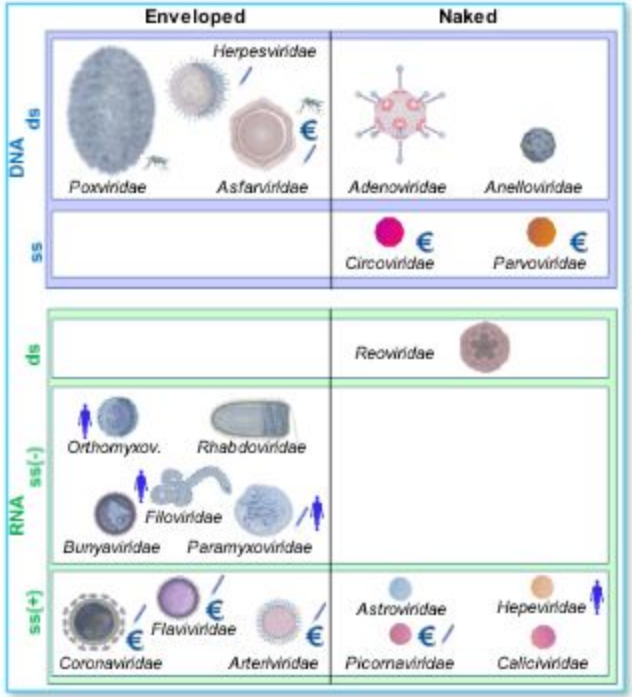
Chapter 36 Virus diseases in swine

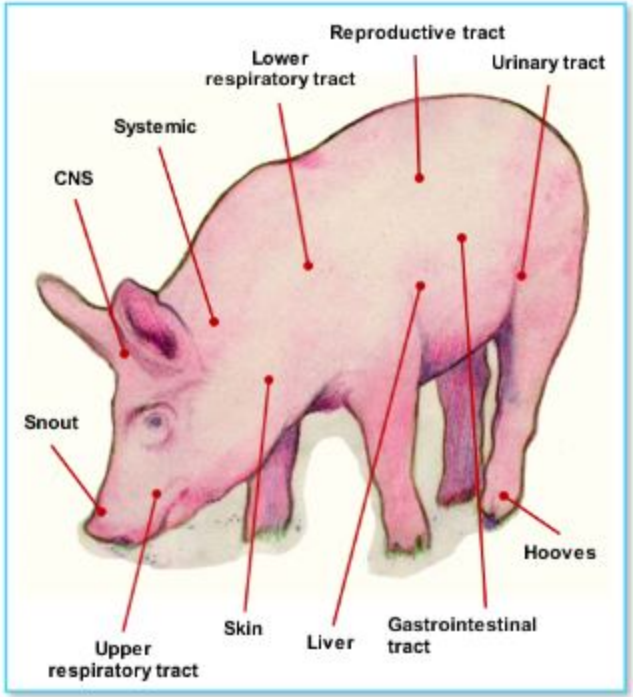
Many viruses affect pigs. In modern farms pigs live close together and have many chances of transmitting diseases from one to the other. Thus, many viral diseases have high morbidity.

Swine viral diseases have produced big losses in the pig industry, as they are systemic (the swine fevers) or affect production, creating either sterility in sows, reproductive failure or piglets which are weak and do not thrive. We have chosen examples of both circumstances.

Which virus affect swine?



Viral diseases and severity



Some viral diseases

African Swine Fever (ASF)

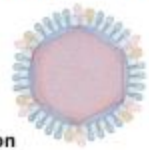
1. The virus (ASFV)
2. Epidemiology
3. Transmission
4. The disease
   - Pathogenesis
   - Clinical signs
   - Medical Prevention

Porcine circovirosis

1. The virus (PCV-2)
2. Epidemiology
3. Transmission
4. The disease
   - Pathogenesis
   - Clinical signs
   - Medical Prevention

Porcine respiratory-reproductive syndrome (PRRS)

1. The agent (PRRSV)
2. Epidemiology
3. Transmission
4. The disease
   - Pathogenesis
   - Clinical signs
   - Medical Prevention



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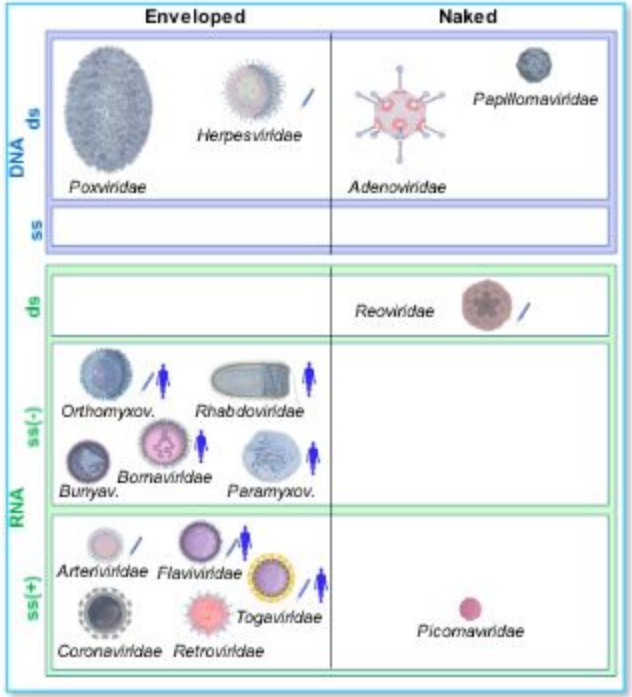
Chapter 37 Virus diseases in horses

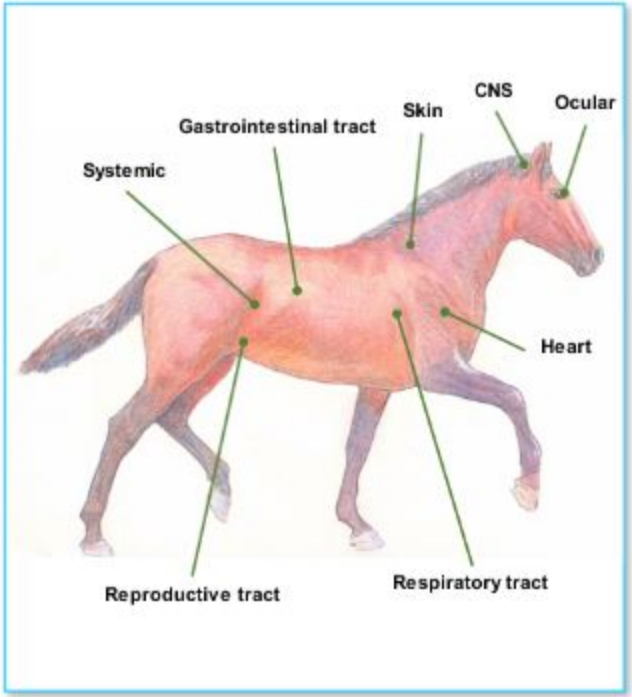
Many viral diseases have been associated with horses; some of them have been known for several centuries (e.g. equine infectious anaemia). Nowadays, many of the viral diseases have an adverse worldwide impact on the sport horse industry, …[+info]

Viral respiratory infections are common in horses and produce severe illness (e.g. influenza or equine viral rhinopneumonitis). Viruses affecting the nervous system are also very important and may affect humans, causing encephalomyelitis in …[+info]

Which virus affect horses?



Viral diseases and severity



Some viral diseases

Equine viral arteritis (EVA)

1. The virus (EVA)
2. Epidemiology
3. Transmission
4. The disease
   - Pathogenesis
   - Clinical signs
   - Medical Prevention

West Nile fever (WN)

1. The virus (WNV)
2. Epidemiology
3. Transmission
4. The disease
   - Pathogenesis
   - Clinical signs
   - Medical Prevention

Equine viral rhinopneumonitis (ER)

1. The virus (EHV)
2. Epidemiology
3. Transmission
4. The disease
   - Pathogenesis
   - Clinical signs
   - Medical Prevention

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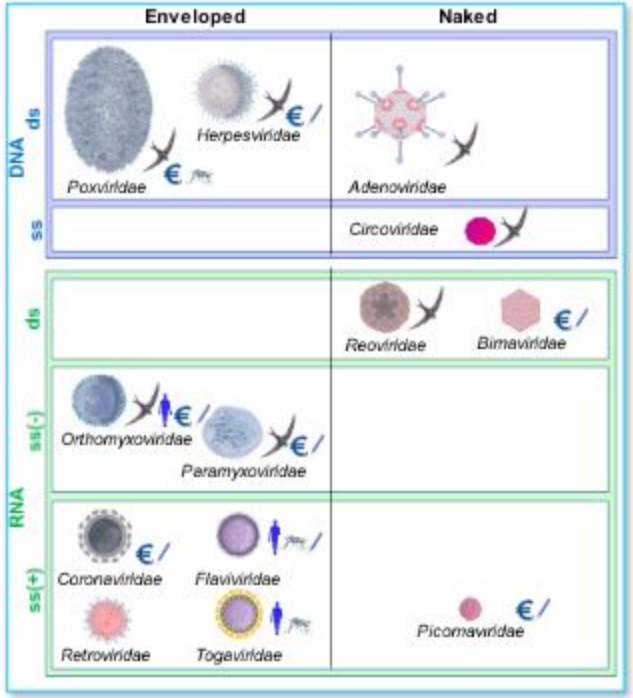
Chapter 38 Virus diseases in birds

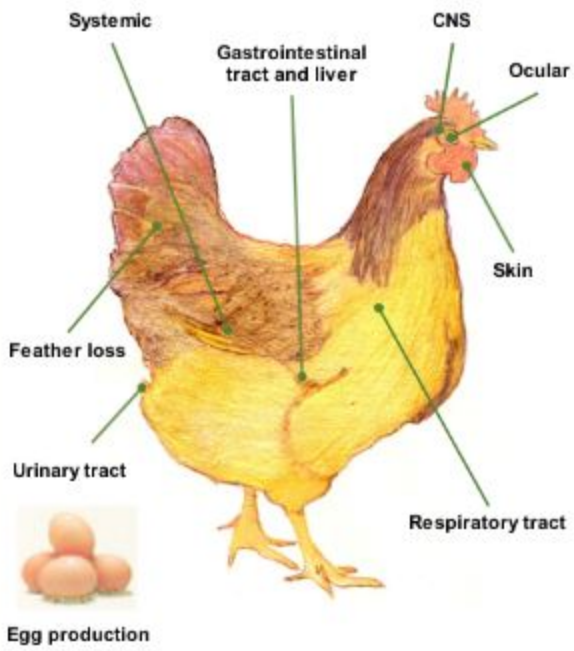
Viral infections can affect poultry, captive or free-living wild birds. Relevant information and vaccines are referred to classical viral infectious diseases that can lead to economic losses in poultry production (Newcastle, Gumboro and Marek´s diseases, Turkey rhinotracheitis, Infectious laryngotracheitis or Infectious bronchitis).

Recently some of these diseases have taken one new dimension in wild birds (Newcastle disease, avian smallpox, duck plague) or have become new zoonotic forms (avian influenza). Wild birds are also the primary hosts for many zoonotic arboviruses (arthropod-borne virus) like West Nile virus, most of them from *Flaviviridae or Togaviridae*...[+info]

Which virus affect birds?



Viral diseases and severity



Some viral diseases

Newcastle disease (ND)

1. The virus (NDV)
2. Epidemiology
3. Transmission
4. The disease
   - Pathogenesis
   - Clinical signs
   - Medical Prevention

Avian influenza (AI)

1. The virus (AIV)
2. Epidemiology
3. Transmission
4. The disease
   - Pathogenesis
   - Clinical signs
   - Medical Prevention

Infectious bursal disease or Gumboro disease (IBD)

1. The virus (IBDV)
2. Epidemiology
3. Transmission
4. The disease
   - Pathogenesis
   - Clinical signs
   - Medical Prevention

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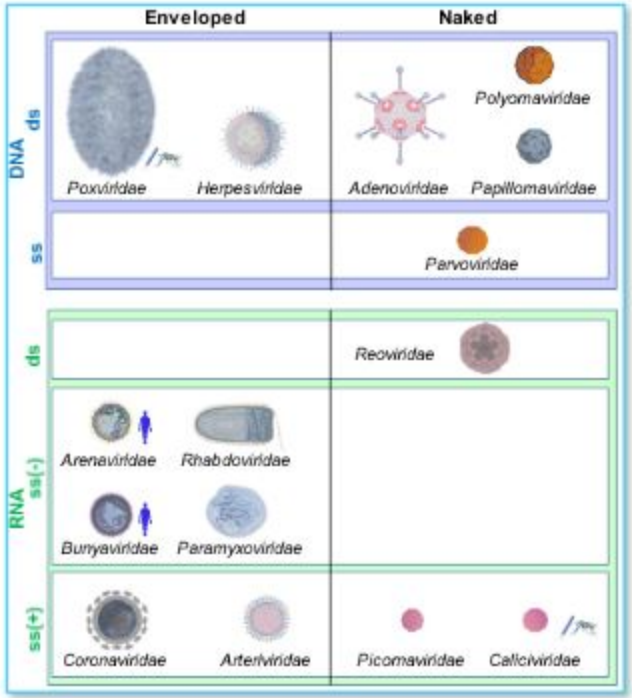
Chapter 39 Virus diseases in rabbits and rodents

Viruses that affect rabbits and rodents are important pathogens in free-living or farmed, laboratory or pet animals. In addition, some of these diseases can be zoonoses, affecting humans. ...[+info]

Historical animal models include various species of rodents and rabbits, which have been indispensable for the discovery of human pathogens and for understanding their pathogenesis, or testing vaccines and treatments. Most of the viral diseases of ...[+info]

Which virus affect rabbits or rodents?



Viral diseases in rabbits

Rabbit haemorrhagic disease (RHD)

1. The virus (RHDV)
2. Epidemiology
3. Transmission
4. The disease
   - Pathogenesis
   - Clinical signs
   - Medical Prevention

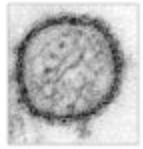
Mixomatosis

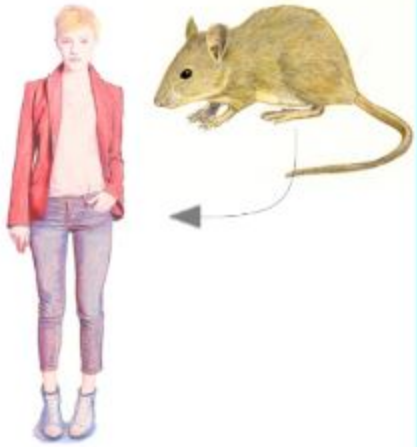
1. The virus (MYXV)
2. Epidemiology
3. Transmission
4. The disease
   - Clinical signs
   - Prevention

Viral diseases in rodents

Infection with hantavirus

1. The virus (Hantavirus)
2. Epidemiology
3. Transmission
4. The disease
   - Pathogenesis
   - Medical Prevention





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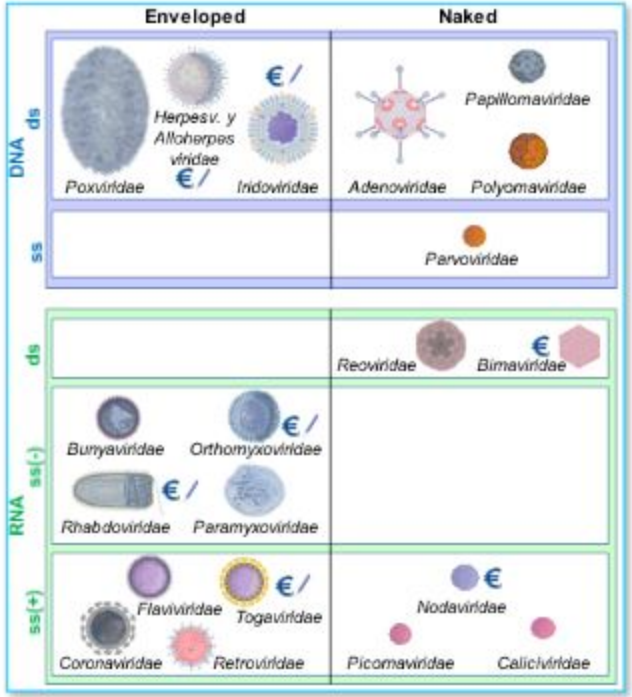
Chapter 40 Virus diseases in lower vertebrates

A vast array of fish species is farmed in high density in freshwater, brackish and marine systems. On-farm stresses may compromise their ability to combat infection, and farming practices facilitate rapid transmission of disease. Viral pathogens are ...[+info]

The aetiology of amphibian and reptilian viral diseases can be attributed to a wide range of viruses. Moreover, viral infections may play a role in the establishment of bacterial, fungal, and parasitic diseases and are an underlying cause of ...[+info]

Which virus affect fish, amphibians or reptiles



Fish viral diseases

Viral Hemorrhagic Septicemia (VHS)

In the absence of vaccines and anti-viral treatments, control methods for VHS currently lie in official health surveillance schemes coupled with control measures.

Koi herpesvirus disease (KHVD)

Following the first reports of KHVD the disease has spread in many countries worldwide, predominantly through the trade in koi carp.

Amphibian and reptilian viral diseases

Infection with ranavirus

Ranavirus infections in amphibians have been implicated as a contributing factor in the global decline of amphibian populations.

Herpesvirus infection in reptiles

HERPESVIRUS INFECTION IN TORTOISES

CHELONIAN FIBROPAPILLOMATOSIS IN MARINE TURTLES

In reptiles, Herpesvirus have been detected in lizards, snakes, chelonians and crocodilians.

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Section VI: Plant Viruses

Chapter 41: Generalities of plant viruses

Chapter 42: Pathogenesis

Chapter 43: Symptoms

Chapter 44: Transmission by plant material

Chapter 45: Transmission by aphids

Chapter 46: Transmission by other vectors

Chapter 47: Control of plant viruses

Chapter 41 Generalities of plant viruses

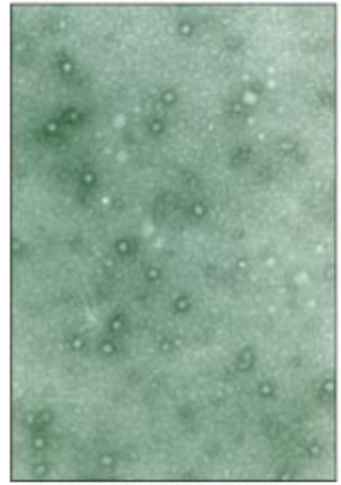
Viruses of plants typically do not infect mammals and they are relatively simple in their structure - it is a package of genetic material (mostly ssRNA+) encapsidated in a protective protein shell. As infective agents, they can be transmitted from diseased plants to healthy ones mechanically by sap, by direct contact of plants or mainly by animal vectors (see Chapters 44-46).

Diseases caused by plant viruses are called plant viroses (Chapter 43) [Bos. 1999. Plant viruses, unique and intriguing pathogens, a textbook of plant virology. Backhuys Publisher, Leiden].

Morphology and size of virus particles typical for ssRNA+ viruses of plants

Rod-shaped elongated, rigid particles, 12-18 x 300nm (1 nm=10^{-9}m)

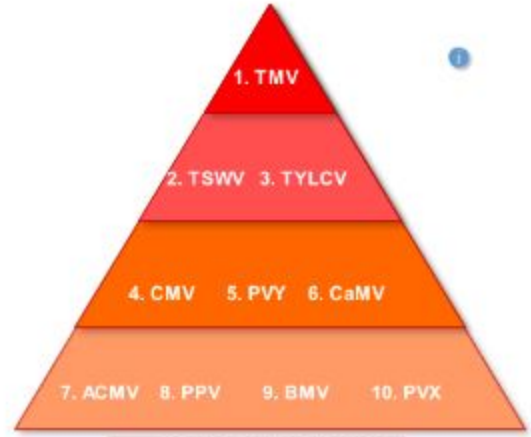
Elongated flexuous particles, 12-15 x 600 - 2000nm (see also Chaper 43)



Isometric (icosaedral) = spherical particles, 25-30 nm diameter

Among plant viruses, with the genome other type than ssRNA+, also differently shaped virus particles exist such as bacilliform particles with rounded ends, 40-80 x 120-180 nm *(Rhabdoviridae, Caulimovirideа: Badnavirus)*. It is worthy to mention that there are viruses with additional lipoprotein envelope (*Rhabdoviridae, Bunyaviridae: Tospovirus*), viruses with two isometric particles forming double structures (*Geminiviridae*) and capsid-less RNA viruses (*Ophioviridae, Tenuivirus, Umbravirus*).

Top 10 plant pathogenic viruses

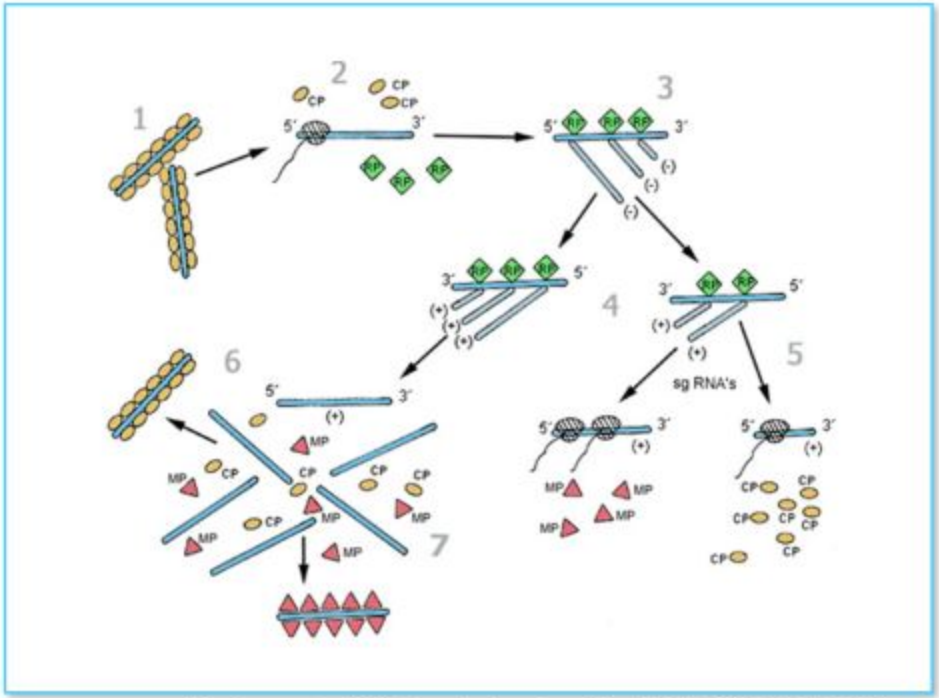


Chapter 42 Pathogenesis

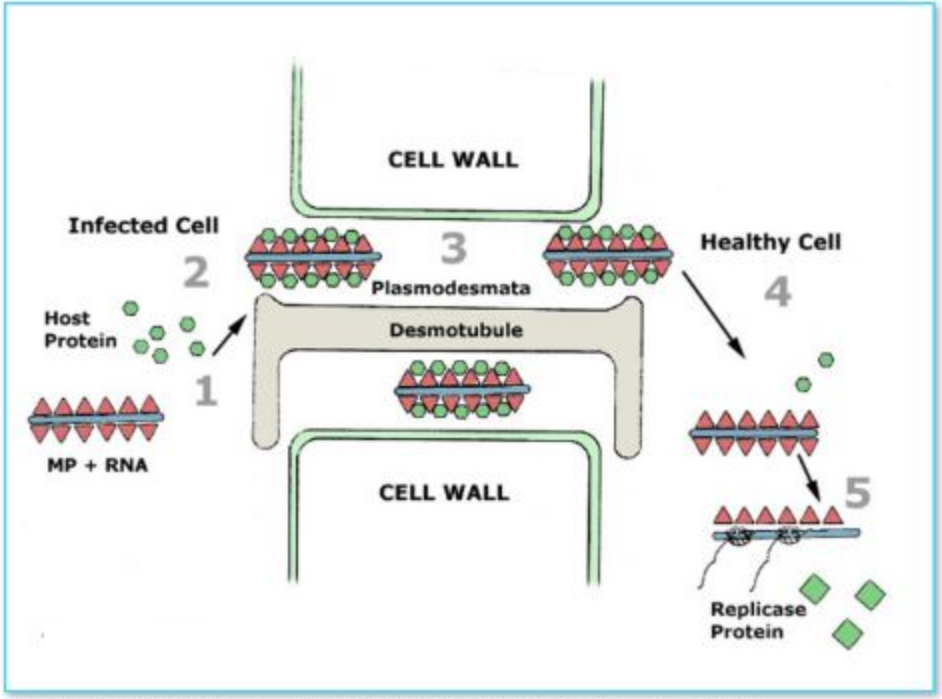
Plant viruses are pathogens which disrupt the cell translation ribosomal system. The virus rearranges it to work for the production of viral proteins instead of working for the production of plant proteins. For the replication they also utilize the energy of the plant cell (ATP) and cellular substrates (nucleotides and amino acids).

Although plant viruses are restricted to the intracellular compartments, their movement from cell to cell occurs through highly regulated channels - the plasmodesmata. The process is mediated by virus-encoded proteins called "movement proteins". They alter the gating capacity of the plasmodesmata to allow the infectious genome to pass to neighbouring cells.

Replication cycle of ssRNA+ plant virus (*Tobacco mosaic virus*)



Cell to cell movement of *Tobacco mosaic virus*



*Drawings courtesy Vickie Brewster; Reproduced from Scholthof, K.-B. G. 2000. Tobacco mosaic virus. The Plant Health Instructor. DOI: 10.1094/PHI-I-2000-1010-01. Updated 2005. APS Education Center. (www.apsnet.org/edcenter)

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Chapter 43 Symptoms

All plant viruses parasitize plant cells and cause numerous diseases. Almost all of them cause some degree of stunting of the entire plant and reduction in total yield.

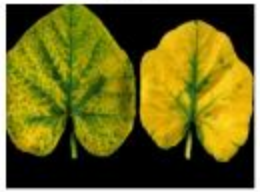
Various symptoms often appear in combination in particular diseases. Symptoms may be local or systemic. Plant virus infection could be symptomless.
To see the description of the symptoms place the cursor in the middle of the image.

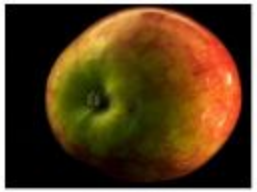
Colour deviations


Mosaic


Chlorosis


Line pattern


Vein banding


Ringspot


Mottling

Malformation and reduction in growth


Dwarfing


Flowers growth reduction

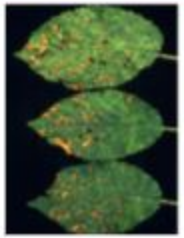

Necrotic spots


Fern-leaf symptom


Enations


Rhizomania

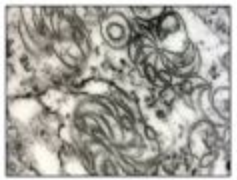
Tissue and plant death (necrosis)

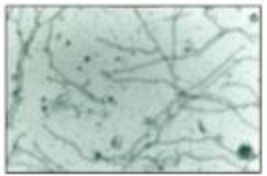

Local necrosis and ringspots


Vein necrosis


Phloem necrosis

Cytological effects of plant virus infections


Cylindrical cytoplasmic inclusion


Presence of virions in infected cells

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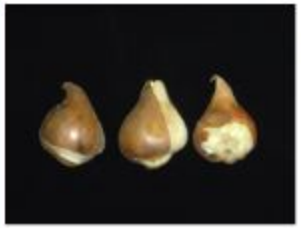
Chapter 44 Transmission by plant material

Propagation of plants can be via sexual (seeds) or asexual (vegetative) mechanisms. Whenever plants are propagated vegetatively by using natural plant organs or during horticultural methods (budding, grafting), any viruses present in the mother plant will be transmitted to the progeny.

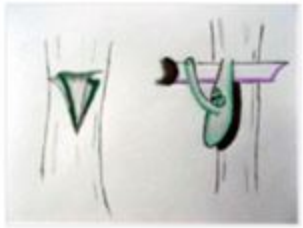
All plant viruses (except cryptic viruses) are transmitted this way. Approximately 20% of plant viruses are transmitted by seeds. Most seed transmission results from embryo infection. Infected pollen could also carry plant viruses.

Vegetative propagation of plant material



Bulbs

Rhizomes



Budding

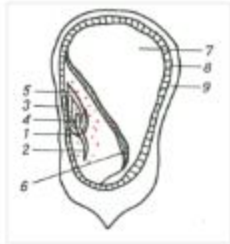
Tissue culture (micropropagation)

Division of plants

Cuttings

Different methods of grafting

Seeds and pollen (red dots = virus particles)



Longitudinal section of corn seed (Virus particles present in the embryo)

Stamens (anthers) of apple flower with many grains of pollen

Tomato seeds. Virus particles present on the seed surface only. Contamination of seeds by TomMV.

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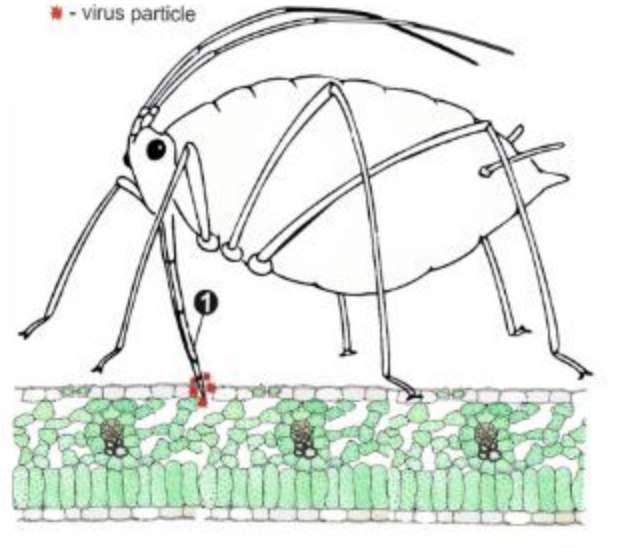
Chapter 45 Transmission by aphids

The most common and economically most important means of natural spread of plant viruses is by insect vectors having piercing and sucking mouth parts. Aphids can carry virus particles on their stylets - it is called non-circulative (non-persistent) manner, or in the circulative (persistent) manner.

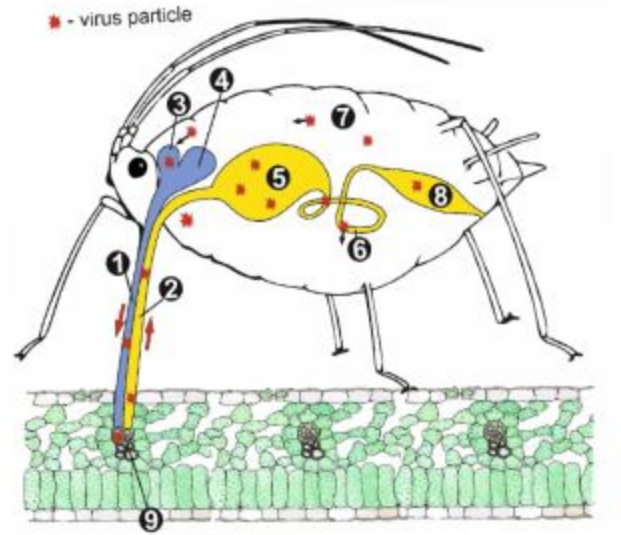
The virions must circulate within the vector through the aphid digestive system, to the salivary glands, before their transmission. Some of the persistent viruses may also replicate in vectors cells and they are classified as **circulative**, **propagative** viruses.

Aphids non-persistent transmission - *Potato virus Y*, PVY



Reversible retention of virus particles at stylet tip. Protein HC (helper component) exists as an accessory factor for virus transmission.

Aphids persistent transmission - *Beet mild yellowing virus*, BMYV



Within the vector, virions travel through the food canal (2) and foregut (5), into the midgut (6) and hindgut (8) where they have to cross cellular and tissue barriers to access the homecoel cavity and with the hemolymph (7) circulate towards the accessory salivary gland (3). After passing the second cellular barrier of gland, virions finally reach the saliva (1). [Annu.Rev.Phytopathol.2013.51:177-201]

Chapter 46 Transmission by other vectors

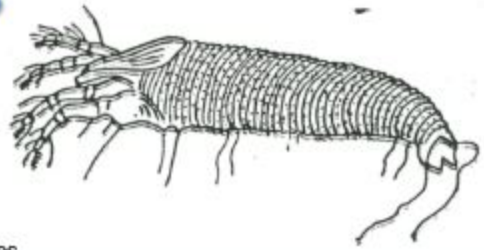
Beside the aphids, the most numerous and versatile group of insect vectors, plant viruses can be transmitted also by thrips, whiteflies, spider-mites, nematodes and by zoospores of protozoa and fungi.

Please remember! There is a very strong contribution of **humans** to plant viral diseases, spread mostly by common agricultural/horticultural practices and world-wide markets.

Arthropod and non-arthropod vectors

Thrips

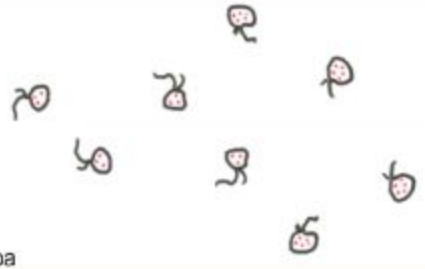
Whiteflies



Mites

Nematodes

Fungi



Protozoa

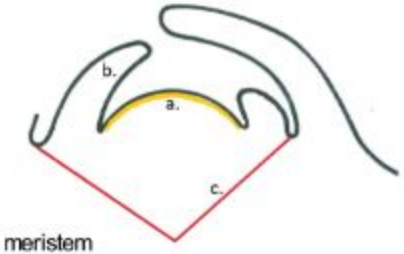
Chapter 47 Control of plant viruses

Generally viral diseases of plants must be prevented. So far there is no direct chemical control of plant viruses. Crop losses may be reduced to acceptable levels by using several integrated methods. Control of plant viral diseases is based on healthy starting plant materials obtained from certificated virus-free vegetative stocks (*e.g.* after thermotherapy, meristem-tip culture or chemotherapy *in vitro* culture) or from virus-free seeds.

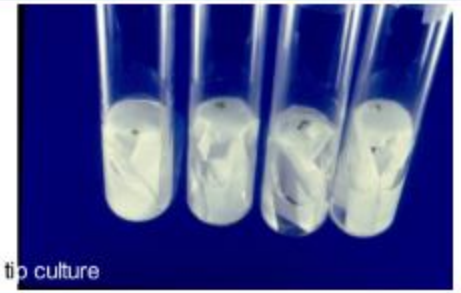
Other methods to protect plants against viruses include:
a) chemical control of virus vectors and weeds - virus natural hosts,
b) use of resistant varieties for plant production,
c) removal of sources of infection and use of any other agritechnical methods useful for plant protection, and d) conformity to quarantine regulations.

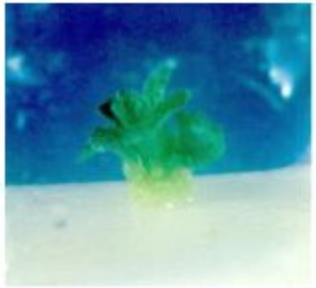
Systems for eradicating plant viral diseases


Heat treatment

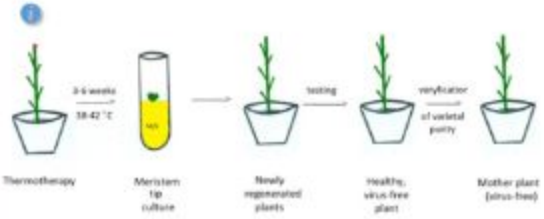


Plant apical meristem


Meristem tip culture


Growing explant


Plants *in vitro* culture



Virus-free plant production

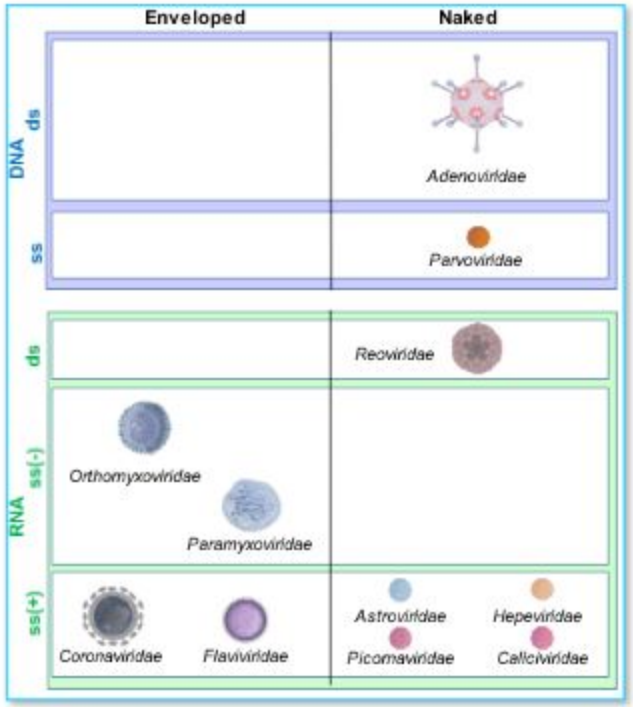
Section VII: Food virology

Chapter 48 Introduction to food virology

Viruses can contaminate food. Although they do not multiply in food, they may persist for extended periods of time as infectious particles. Therefore, foodborne viruses are identified as a significant hazard in food. Viruses are the second most-reported cause of ...[+info]

Foodborne transmission has been described for many different viruses associated with various diseases. Most reported incidents of viral foodborne illness are due to viruses that cause gastroenteritis (norovirus, sapovirus, rotavirus, ...[+info]

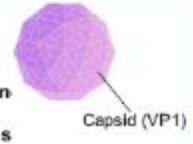
Virus involved in foodborne outbreaks



Most important viral diseases

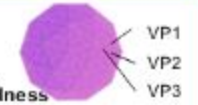
Human norovirus

1. The virus (HNoV)
2. Infectious dose
3. Incubation period and symptoms of illn
4. Shedding
5. Transmission routes and food vehicles
6. Environmental stability



Hepatitis A

1. The virus (HAV)
2. Infectious dose
3. Incubation period and symptoms of illness
4. Shedding
5. Transmission routes and food vehicles
6. Environmental stability



Hepatitis E

1. The virus (HEV)
2. Infectious dose
3. Incubation period and symptoms of illness
4. Shedding
5. Transmission routes and food vehicles
6. Environmental stability

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Chapter 49 Sources of food contamination

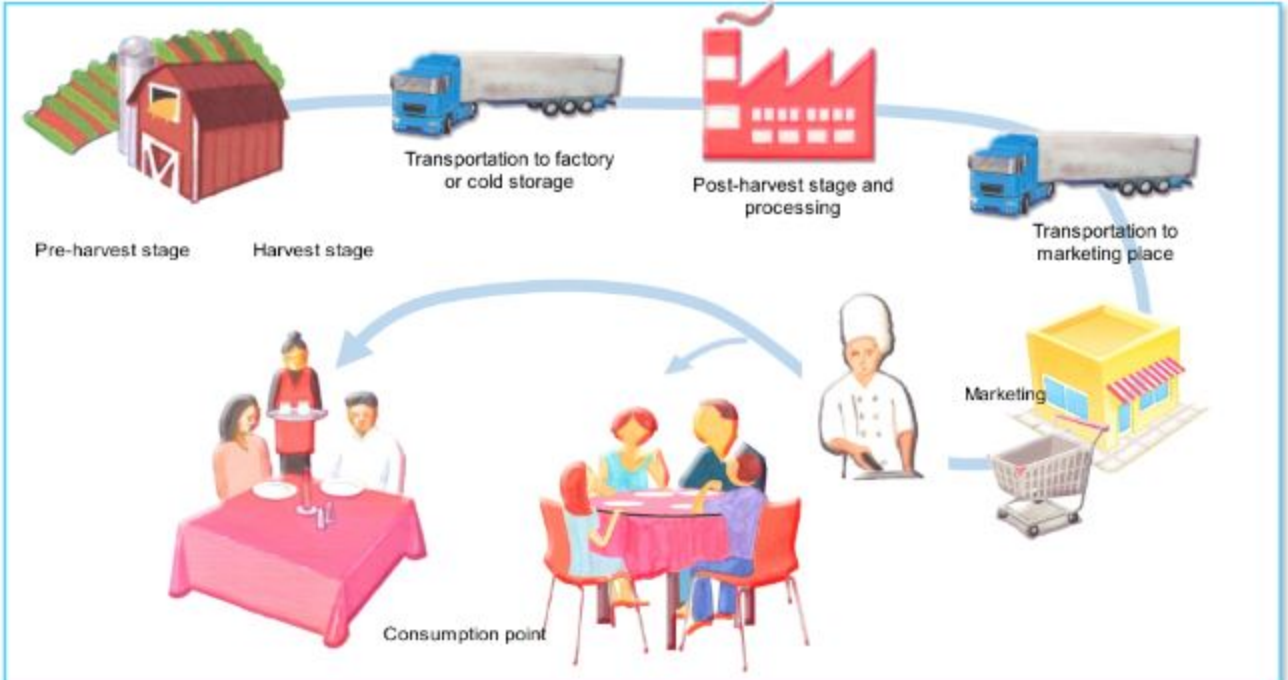
No.1 Source - Contact with faecal material or vomitus - directly or indirectly by contaminated food and/or water.

Contamination can occur at any stage of the food chain production.

The greatest public health concerns are norovirus (NoV) and hepatitis A virus (HAV) in

- Fresh produce: salad vegetables (lettuce, green onion, etc.), berry fruits (raspberries, strawberries, etc.)
- Bivalve filter-feeding molluscs (oysters, clams, mussels, scallops)
- Ready-to-Eat (RTE) food

Points at which food may get contaminated with viruses



Most important weak points

Hands of infected worker/food handler

Proper way to wash hands

Cross-contamination from infected surfaces

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Chapter 50 Virus inactivation in foods

Viruses are able to persist on chilled, acidified, frozen foods and foods packed under modified atmosphere or in dry conditions. Their stability resides in the capsid, which serves to protect the virus from environmental factors such as pH, heat, and ultra-violet (UV) light … [+info]

An important obstacle to establish trustful inactivation rates for different processes and treatments is that the majority of the viruses present on food cannot be cultivated in the laboratory. As they cannot grow in cell culture, … [+info]

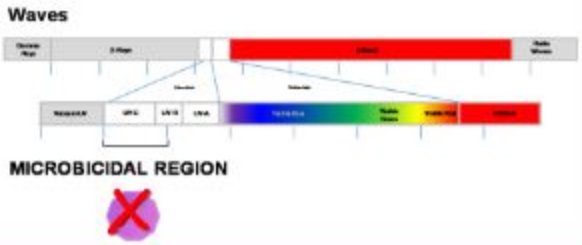
Thermal processes

Non-thermal processes

High hydrostatic pressure processing (HPP)

Photo of an industrial food high pressure processing unit ("Hiperbaric 420" by Hiperbaric)

Ultraviolet light (UV light)



Gamma irradiation

Special label required on irradiated foods - the international symbol of irradiation, known as a "radura".

Section VIII: Prokaryotic Viruses and their Applications

Chapter 51: Morphology of bacterial viruses

Chapter 52: Infection cycle of bacterial viruses

Chapter 53: Ecological role of bacteriophages

Chapter 54: Viruses of *Archaea*

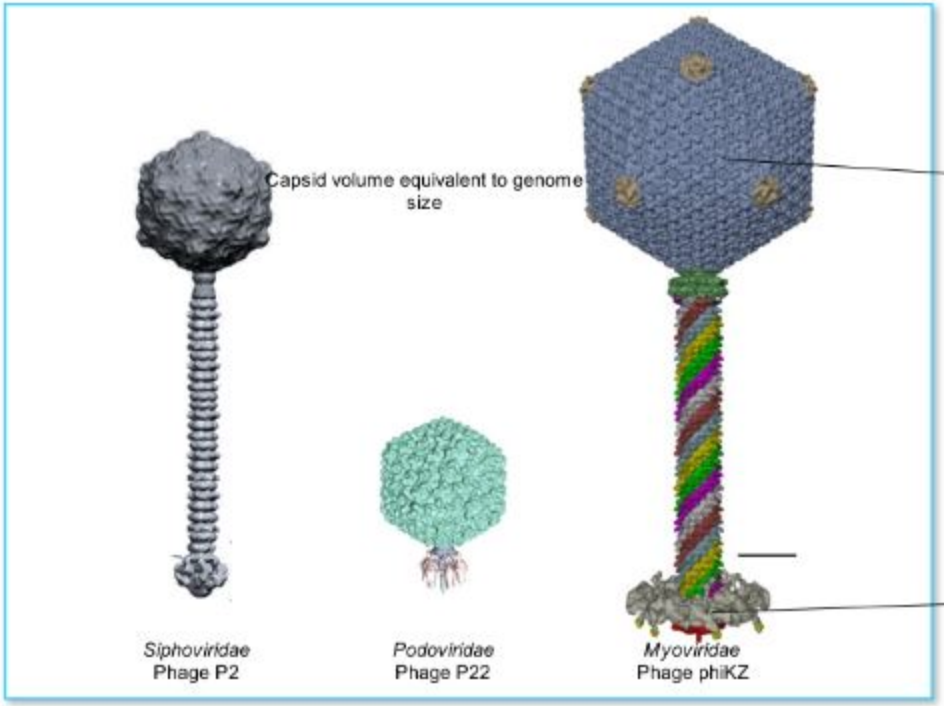
Chapter 55: Using bacteriophages to control bacteria

Chapter 51 Morphology of bacterial viruses

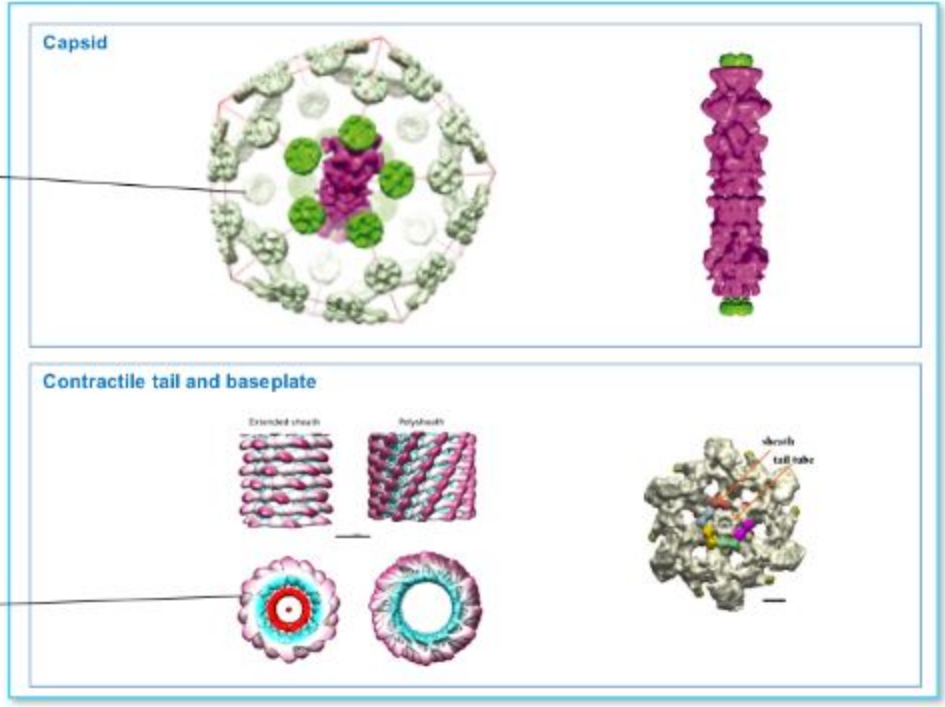
From large viruses to giants - Contrary to other viruses, bacterial viruses or bacteriophages that have been cultured are predominantly (95%) double-strand DNA viruses.

Viruses of the *Caudovirales* (or tailed phages) Order are morpologically distinct by one of three types of DNA injection mechanisms (phage tail). With genomes that can reach >300kb, they are among the largest viruses described.

Families of tailed viruses



Structure



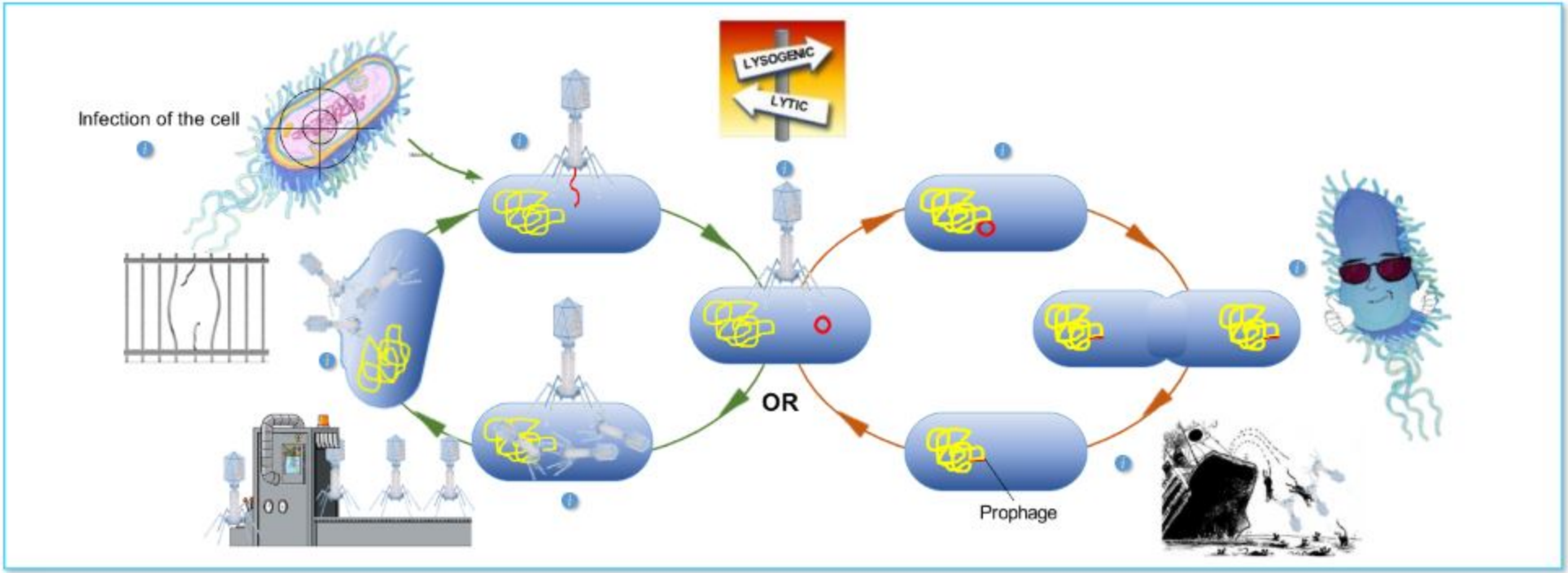
Chapter 52 Infection cycle of bacterial viruses

Bacteriophages may have a lytic cycle or a lysogenic cycle. The lytic cycle involves that the bacterial cell breaks or lyses when the phage replicates. After bacterial lysis, the phages seek other cells to infect. Sometimes, when the extracellular phage concentration is very high, phages will not lyse the cell immediately but rather wait for the adequate conditions (phage inhibition).

In contrast, the lysogenic cycle does not result in the immediate lysing of the host cell, but the genome of these phages will integrate in the host DNA and replicate along with it without inducing any effects (temperate phages). The virus remains dormant until the conditions allow it to become active, replicate and lyse the cell.

Lytic cycle

Lysogenic cycle



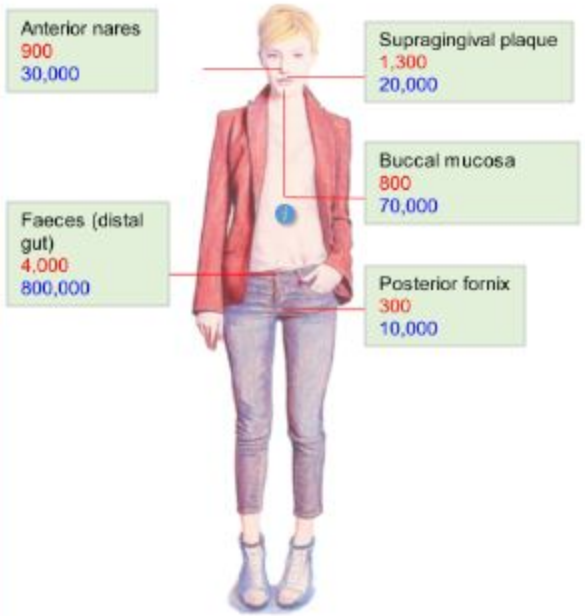
Chapter 53 Ecological role of bacteriophages

Bacteriophages affect our lives in ways we never imagined, from a global scale to regulating the natural bacteria in your gut. Just like the yin-yang, bacteria and their viruses form a carefully balanced equilibrium.

Global role

10,000,000,000,000,000,000,000,000,000,000 (10^{31}) phages are present on Earth.
It's estimated that 20-50% of all bacteria are killed by phages every day, keeping the bacterial numbers "in check".

Role in the body



Consequences in industry

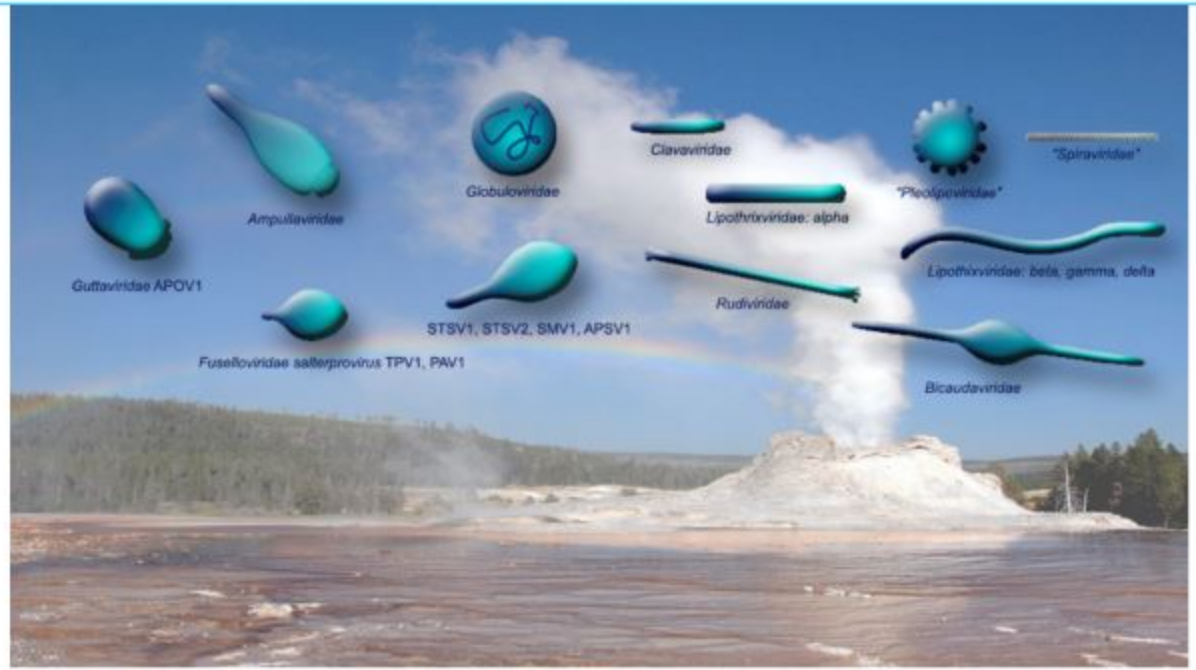
Cheese production is dependent on lactic acid bacteria to ferment the milk. Phages that kill these fermentor culture bacteria cause significant losses in cheese production.

Chapter 54 Viruses of *Archaea*

The evolutionary history of our world reveals three distinct lines of descent: the *Eukarya* (eucaryotes), *Bacteria* and the *Archaea*. *Archaea* are single cell organisms which are found in many environments, including extreme environments.

All of these are predated by viruses. In case of the *Archaea*-infecting viruses, an enormous morphological and biological diversity can be found in the ecological niches where *Archaea* and their viruses are found. Archaeal viruses have been found in very extreme environments including hot-water springs (thermophilic), high salt (halophilic) and acidic (acidophilic) lakes.

Families of *Archaea*-infecting virus



Chapter 55 Using bacteriophages to control bacteria

Bacteriophages as a tool to combat bacterial infections. With the rise in antibiotic resistance, scientists are re-evaluating strictly lytic phages and their potential to combat bacterial pathogens in various fields. This is called "phage therapy", for humans and animals, and "biocontrol", when the target host of a phage is not an animal.

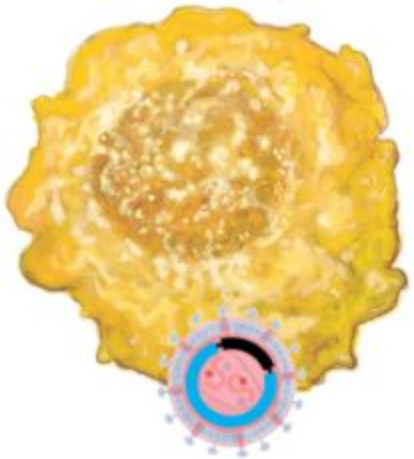
Phages tend to be more successful than antibiotics where there is a biofilm covered by a polysaccharide layer, which antibiotics typically cannot penetrate.

Applications of phages in phage therapy and biocontrol

"I saw that the broth culture, which the night before had been very turbid was perfectly clear: all the bacteria had vanished... I understood: what causes my spots was in fact an invisible microbe, a filterable virus, but a virus parasitic on bacteria.
If this is true, dysentery bacilli in the sick man will have dissolved away under the action of their parasite."

- Felix d'Herelle (1873-1949)

Section IX: Virus Biotechnology



Chapter 56: Biotechnological application of phages

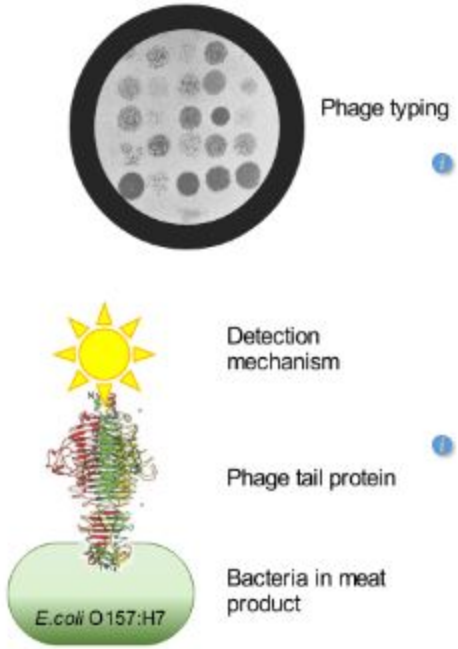
Chapter 57: Application of viruses in genetic engineering

Chapter 56 Applications

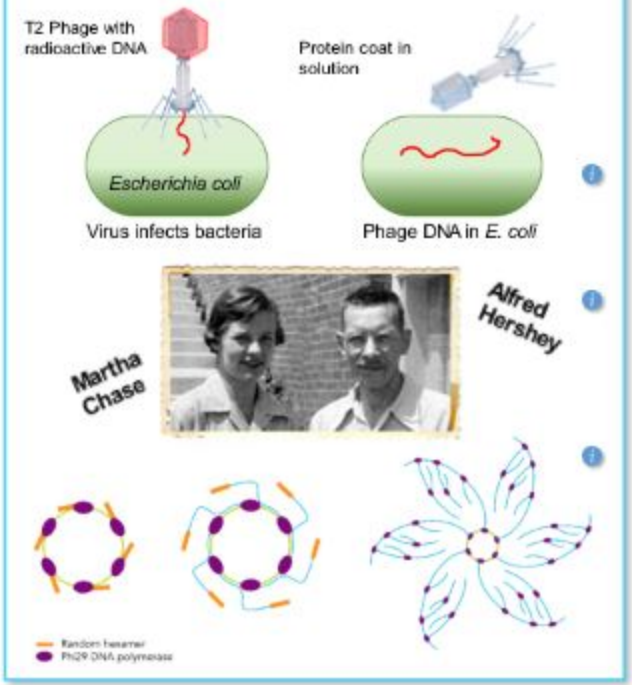
Due to their easy manipulation and production, phages have been the study model for several cellular processes, including the recognition that DNA carries the hereditable information. In recent years it has been recognized that bacteriophages have several potential applications in the modern biotechnology industry.

Phages have been proposed as delivery vehicles for protein and DNA vaccines and for gene therapy; for the detection of pathogenic bacteria; and as tools for screening libraries of proteins, peptides or antibodies. Some recent experiments anticipate a wide array of biotechnological uses of phages in the future.

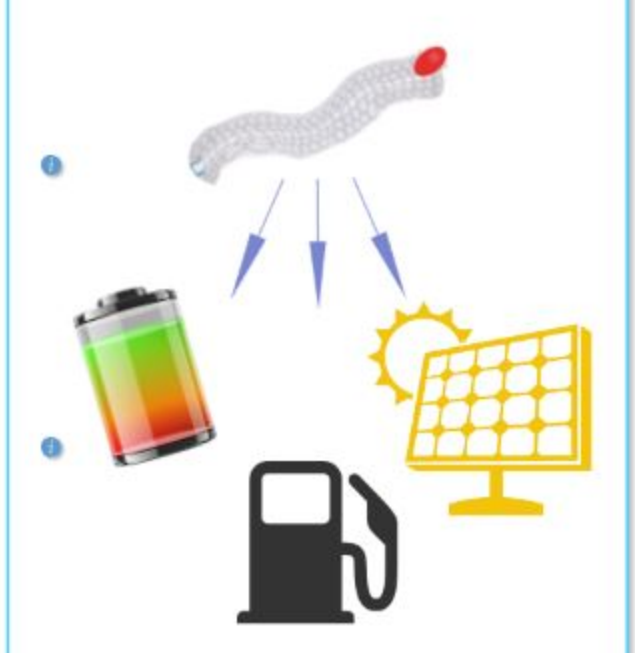
Bacteriophages in diagnostics



Bacteriophages in the lab



Bacteriophages in the industry



Erasmus+

Chapter 57 Applications of viruses in genetic engineering

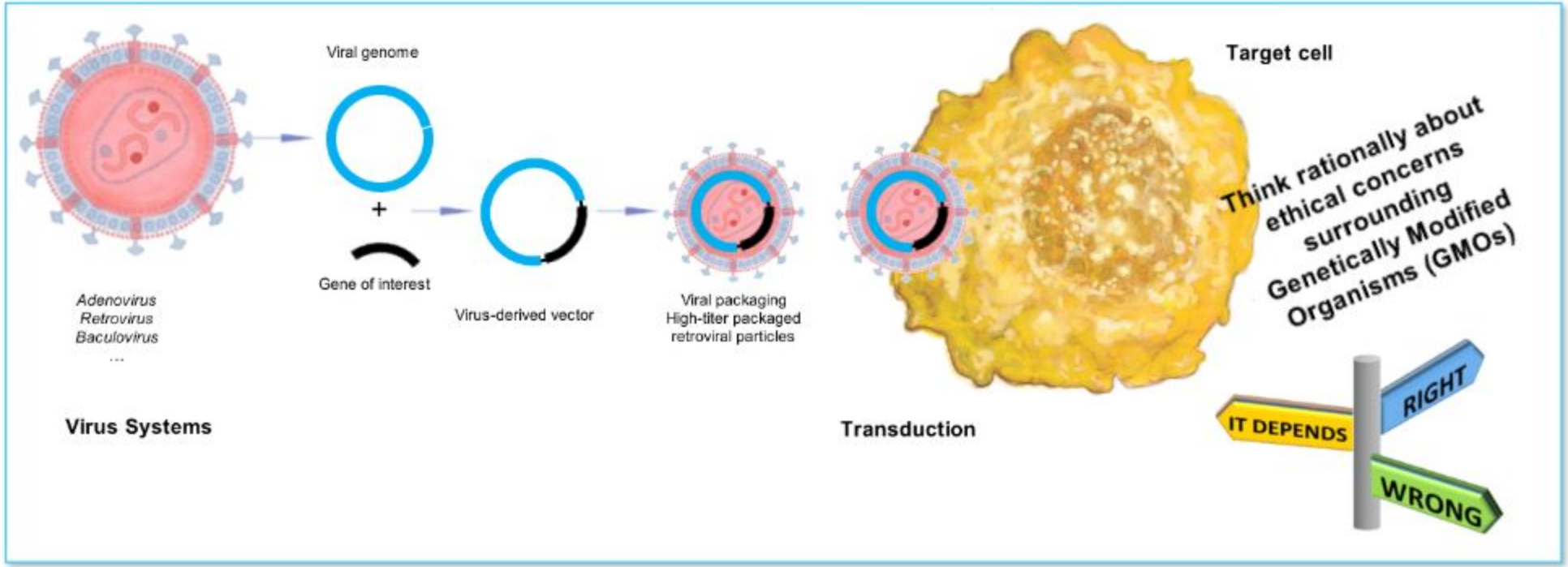
The introduction of (foreign) DNA into animal/plant cell lines can efficiently and easily be delivered by viruses, though some risks exist. In fiction, these risks tend to be exagerated but make nice entertainment.

The choice of viral vector systems depends on the target cells, the transient/stable protein expression of the foreign gene.

SOME DEFINITIONS:

- Transduction : horizontal DNA transfer using a virus infection mechanism.
- Horizontal gene transfer: transfer of genes between organisms in a manner other than the traditional reproduction. It can be achieved *in vitro* (cell cultures) or *in vivo* (gene therapy applications).

Steps for transferring a specific gene into a cell



Check your knowledge

Index

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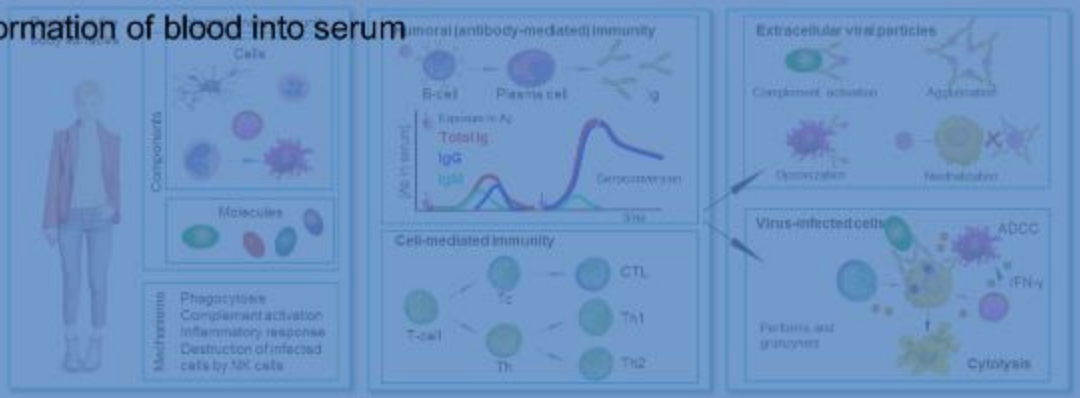
- the presence of T-lymphocytes in blood
- the significant increase of the specific antibody titre
- the presence of immunoglobulins in blood
- the transformation of blood into serum



Viruses may be observed with the light microscope

- True
- False

Which virus life-cycle step is inhibited by the drug “Amantadine” used in cases of Influenza infection

- Uncoating
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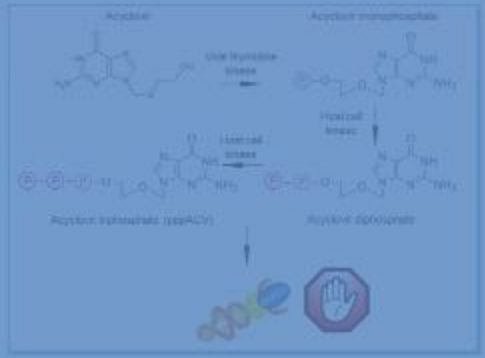

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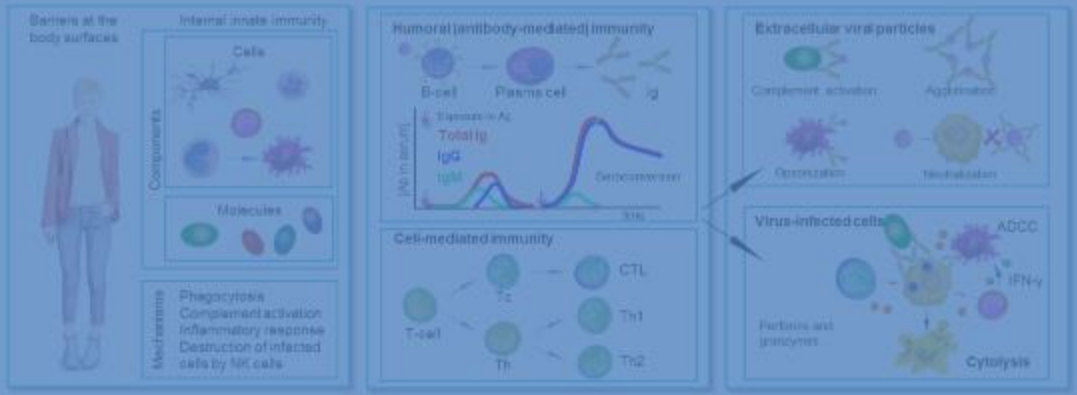
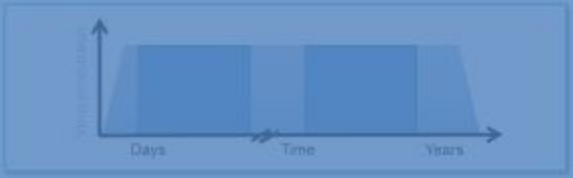
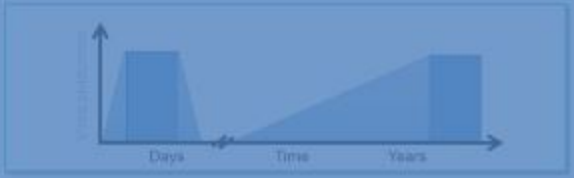


Persistent infections may be :

- chronic or latent
- acute
- latent
- chronic





Influenza viruses evolve through

- Reassortment and mutations
- Reassortment only
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Which of the following would you choose to test the immune response induced by a virus?

- Primary cultures
- Experimental animals
- Chick embryo
- Continuous cell lines

Which of the following are signal transducing molecules in the pathway of Systemic Acquired Resistance - SAR?

- Salicylic acids
- Jasmonic acids
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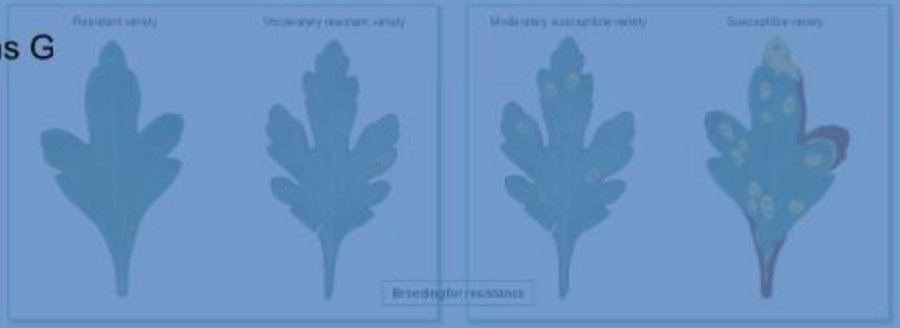

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- Group I
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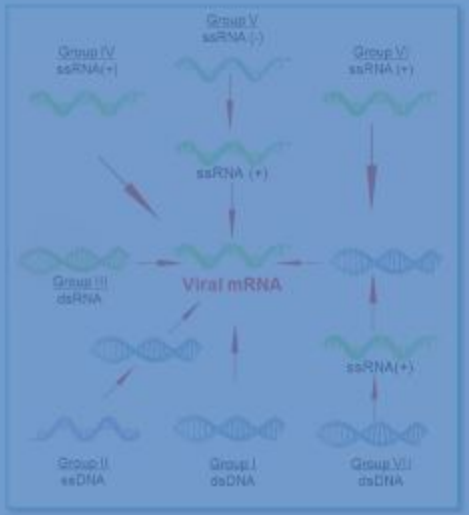

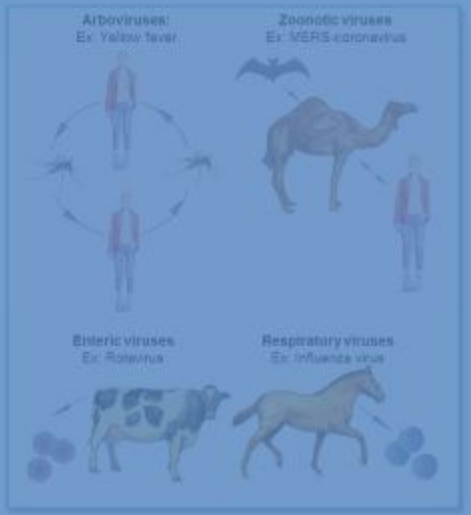

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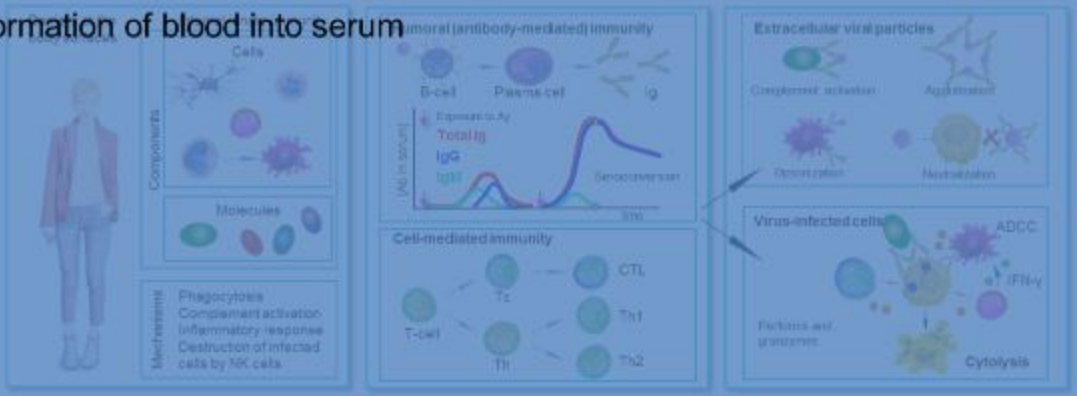

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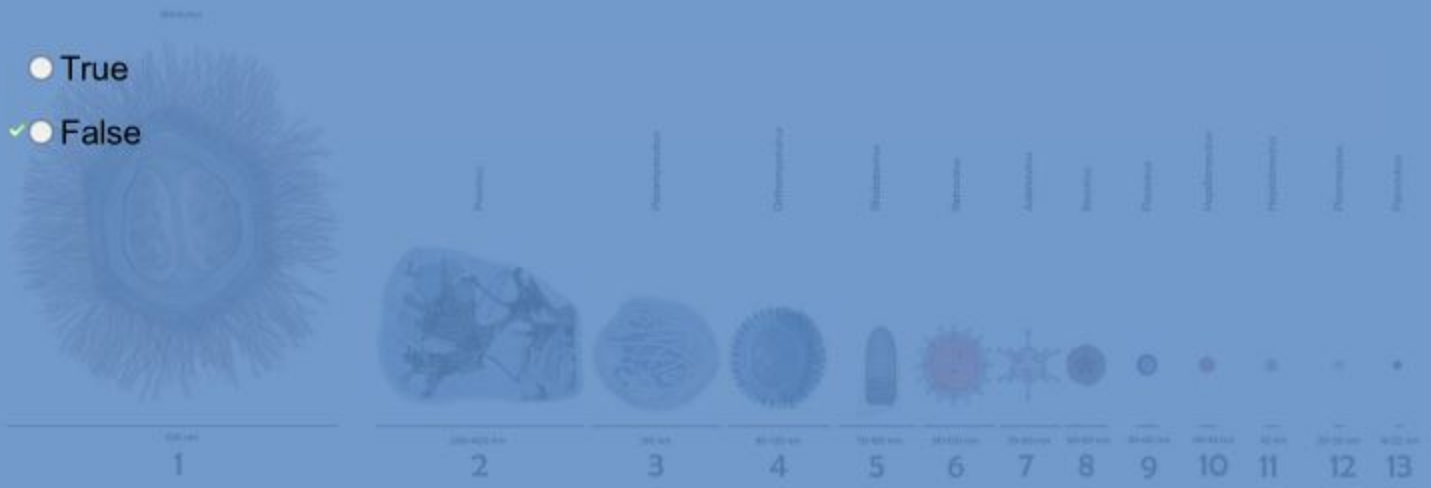

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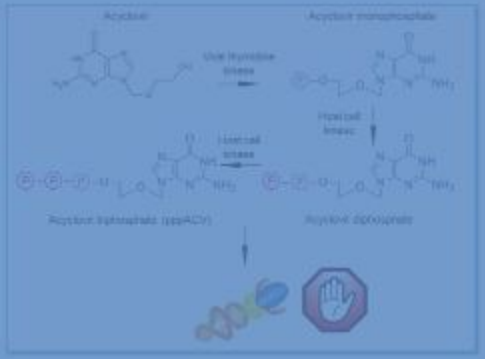

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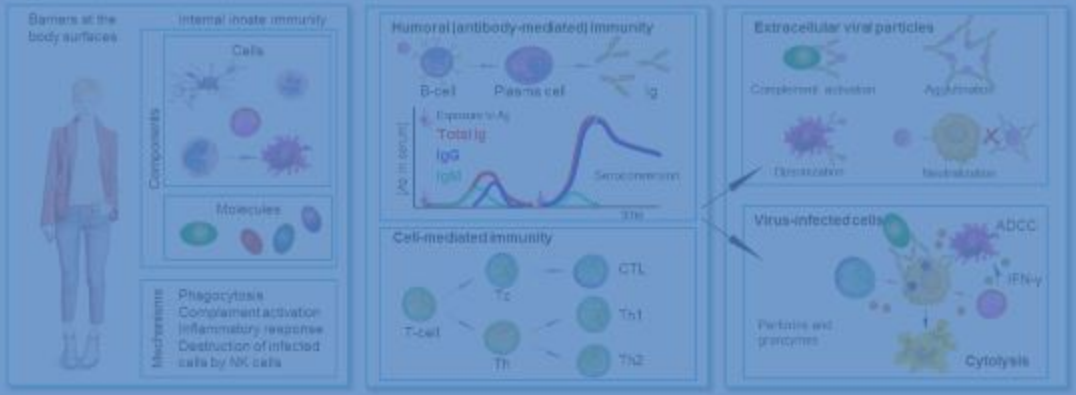

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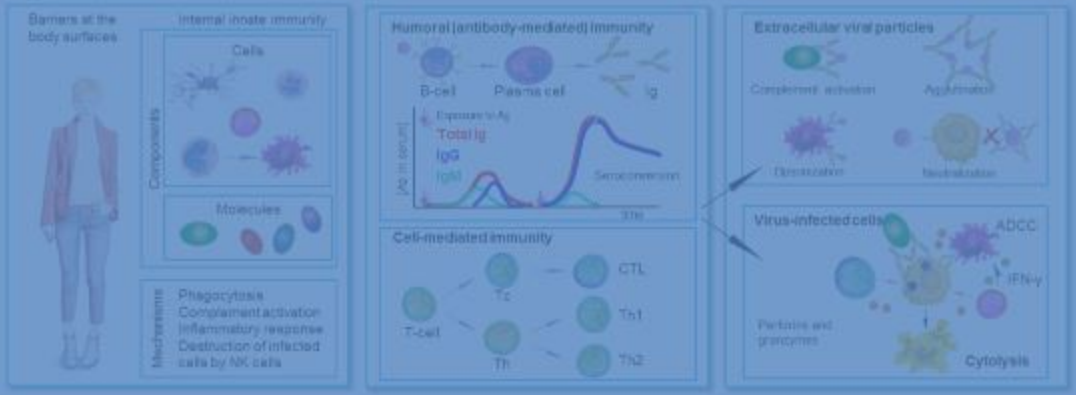

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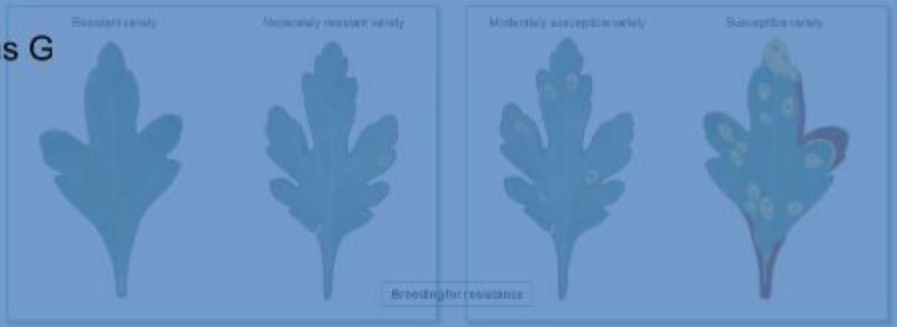

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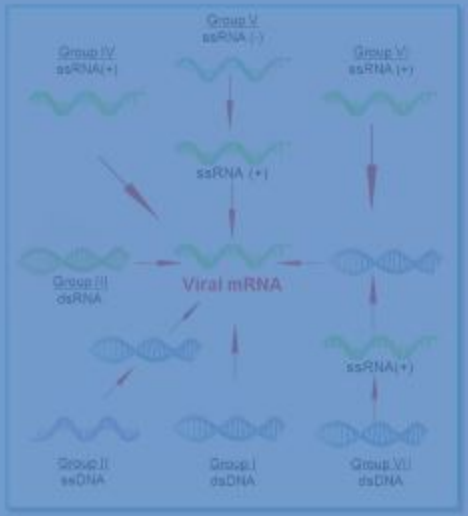

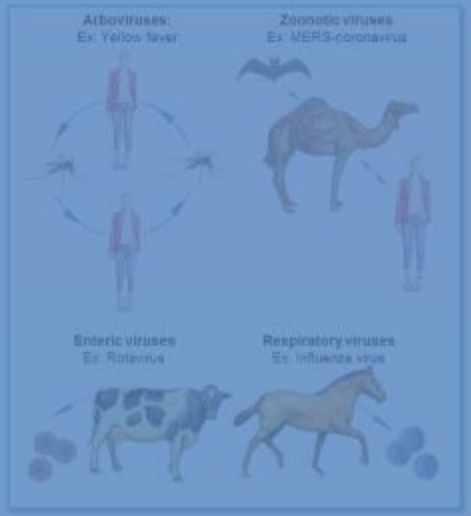

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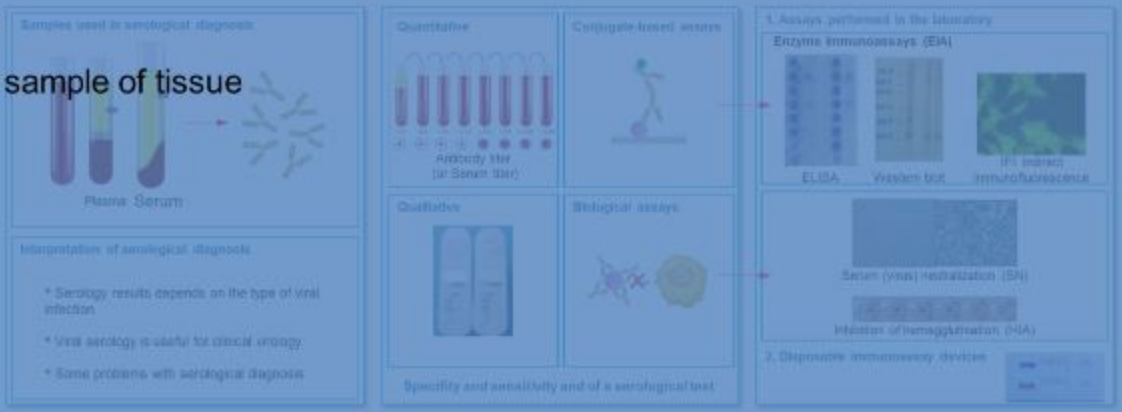

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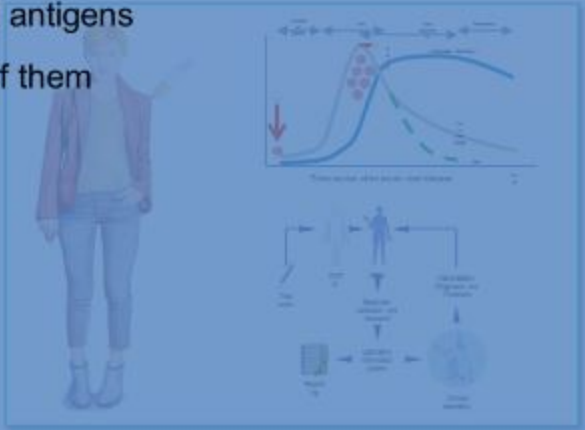
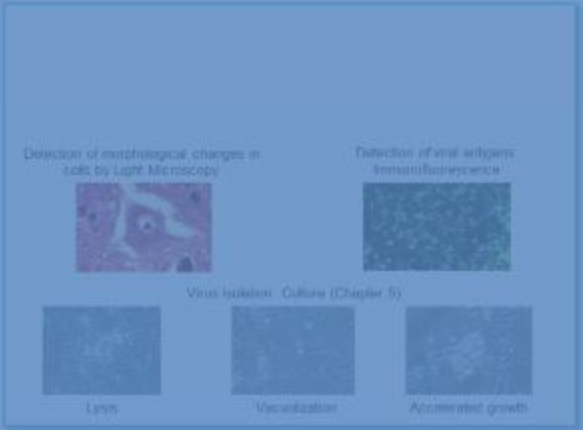
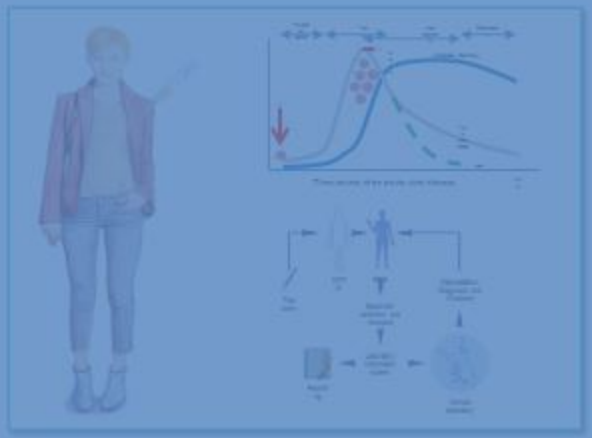
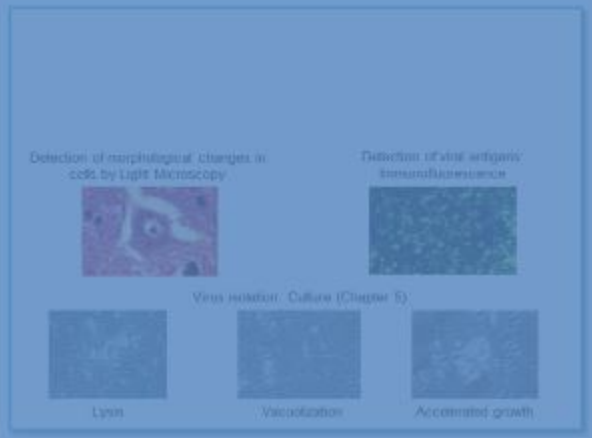




Unscramble the letters IUVOTNLZACAIO **so spell a type of physical alteration that virus cause when replicate in cells**





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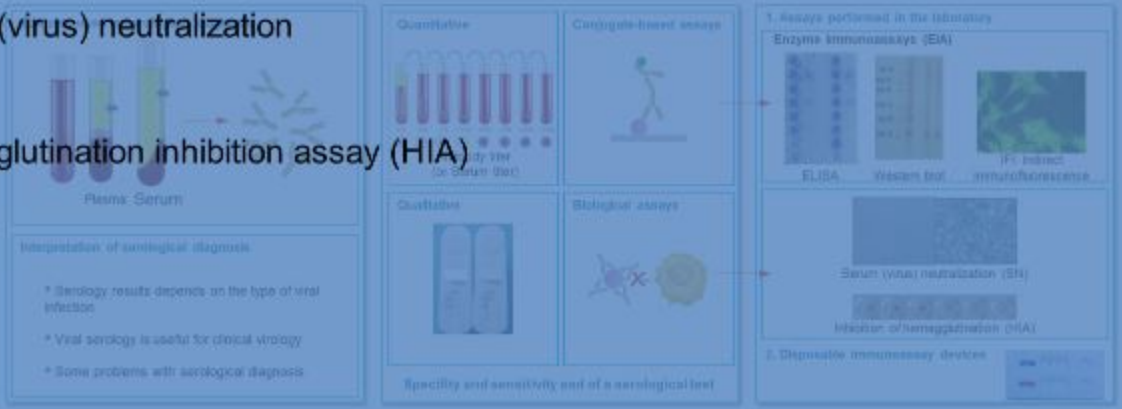

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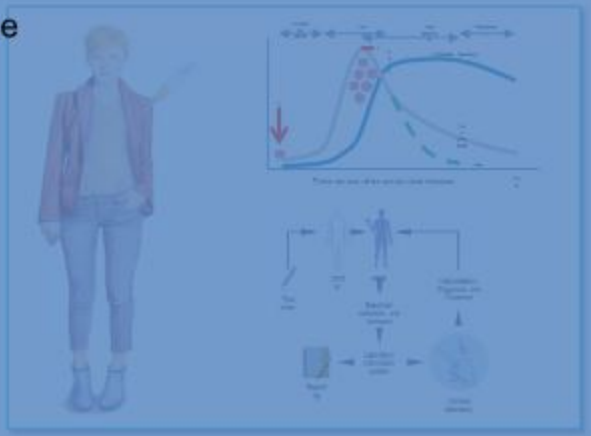

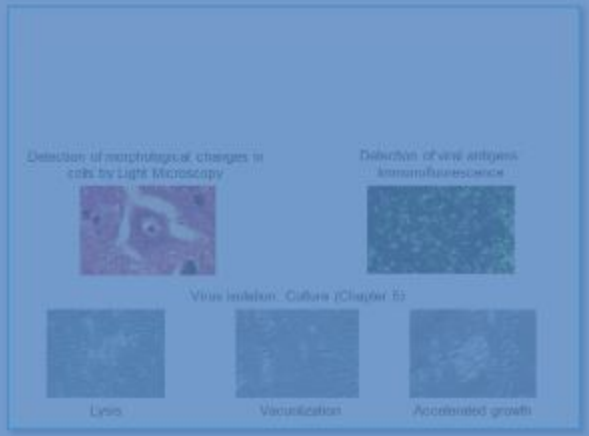

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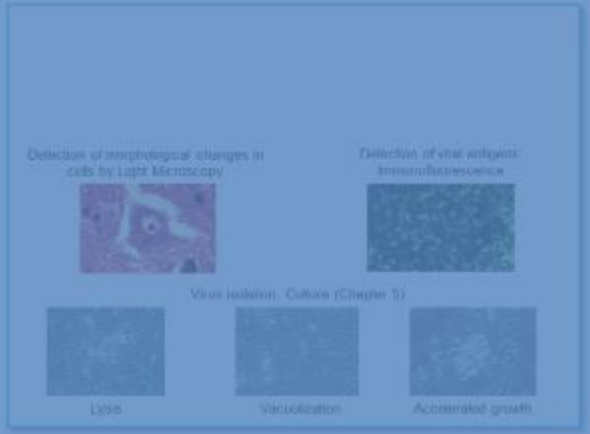

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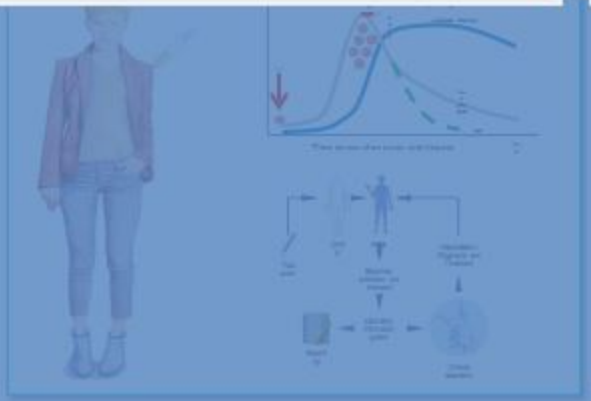

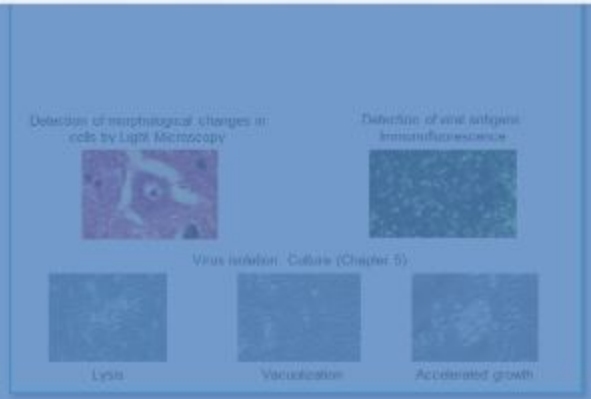

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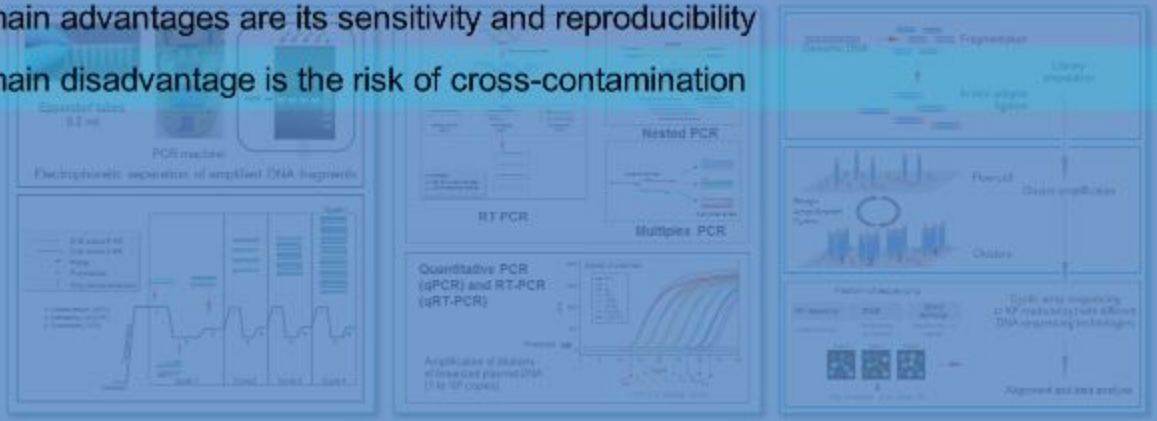

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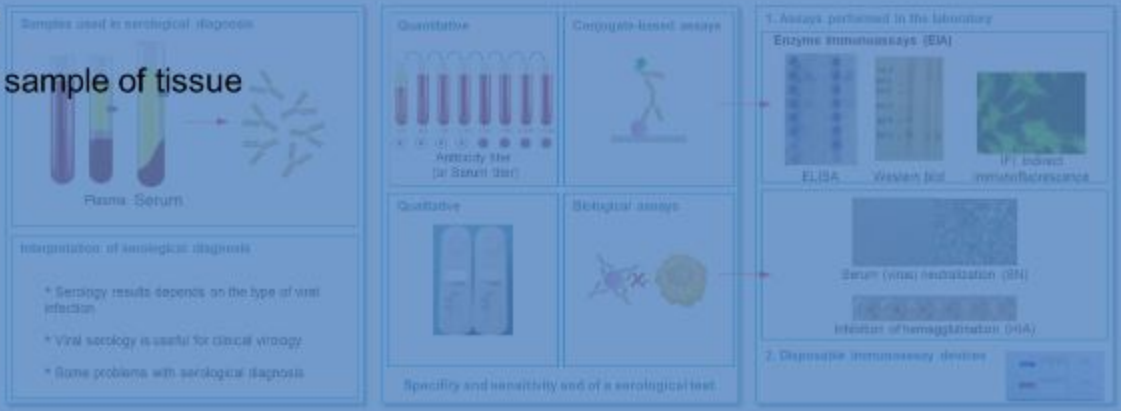

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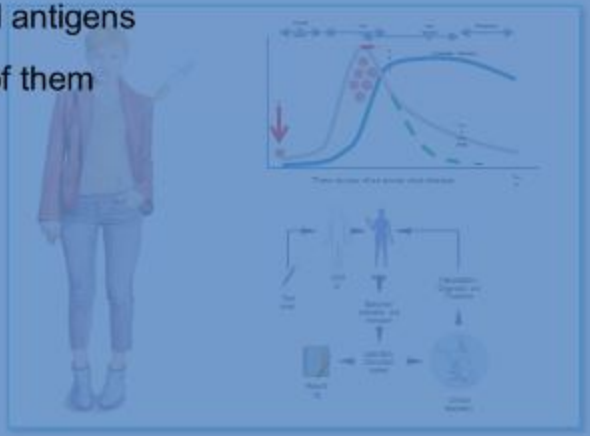

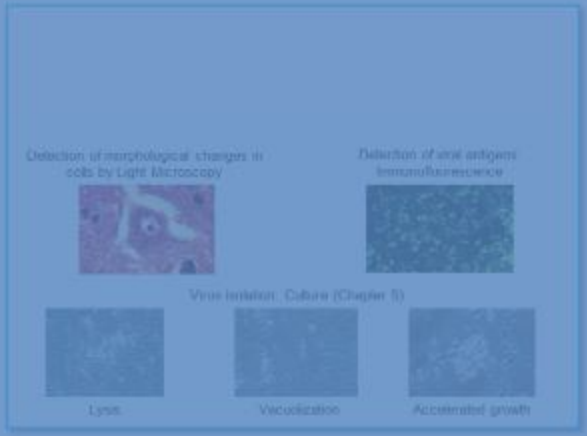

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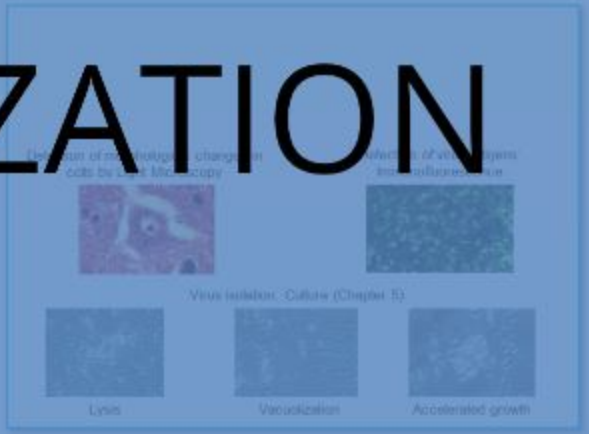
Correct Response

VACUOLIZATION



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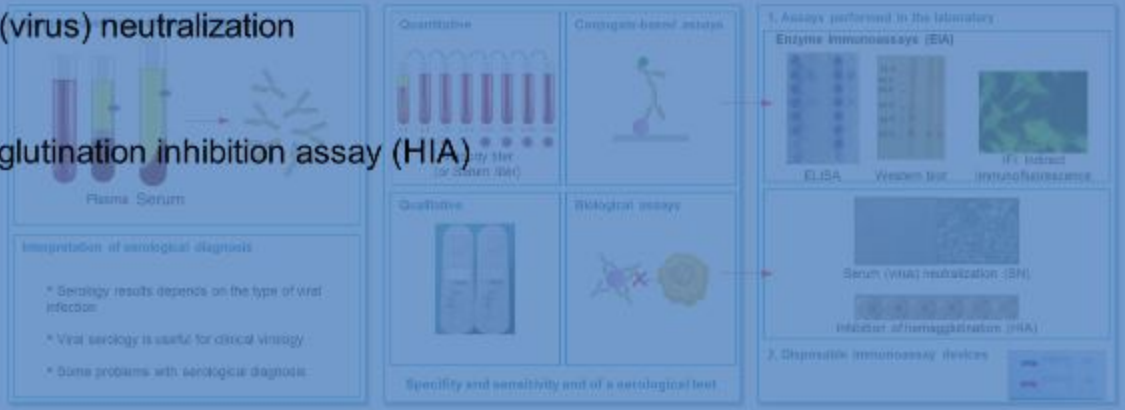

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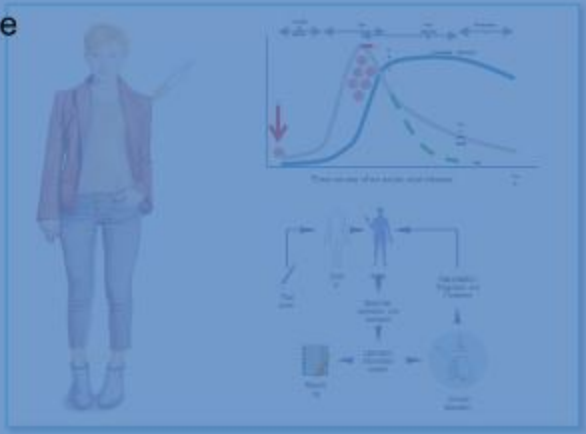

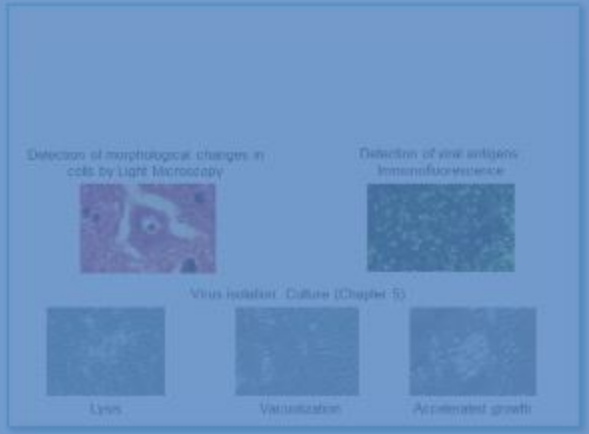

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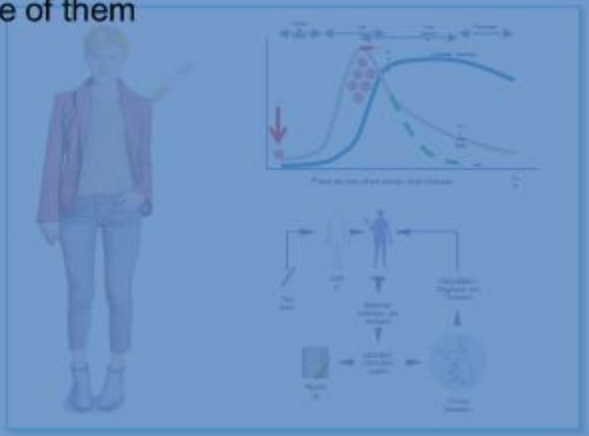

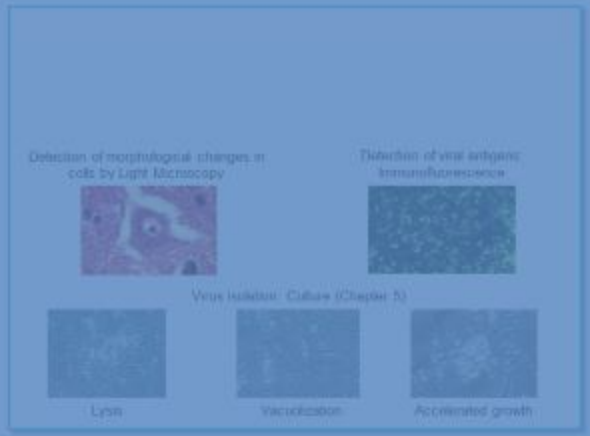

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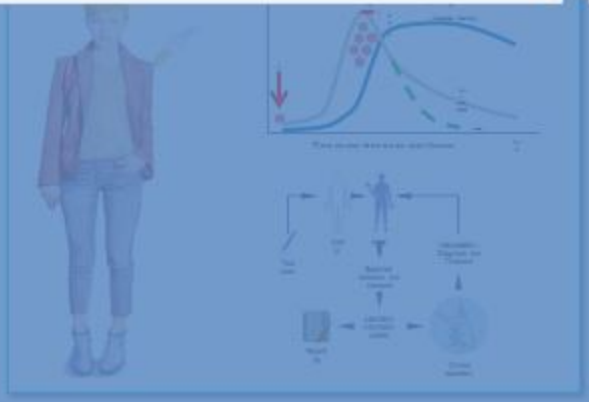

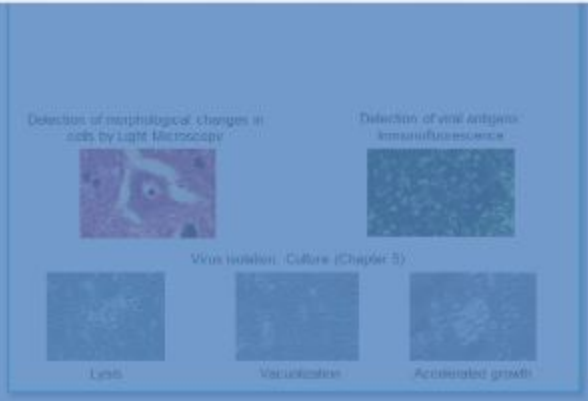

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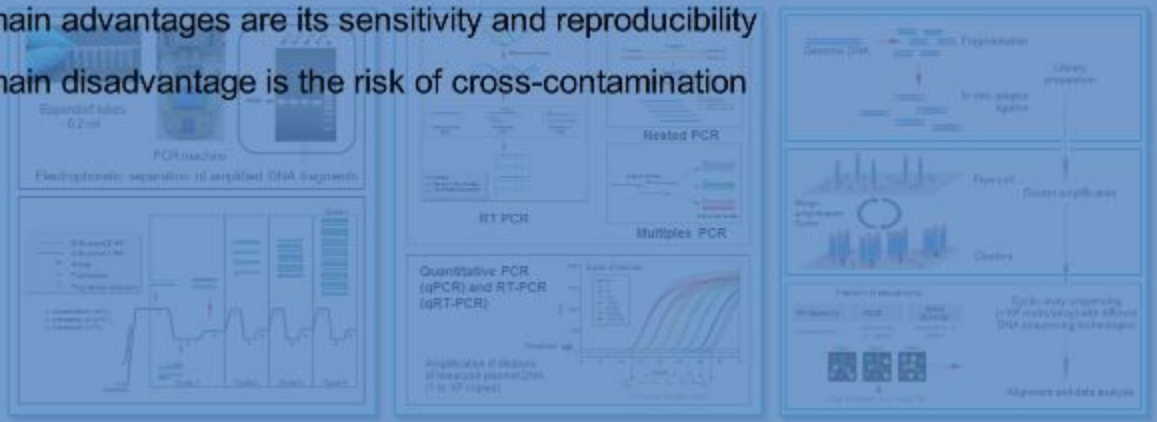

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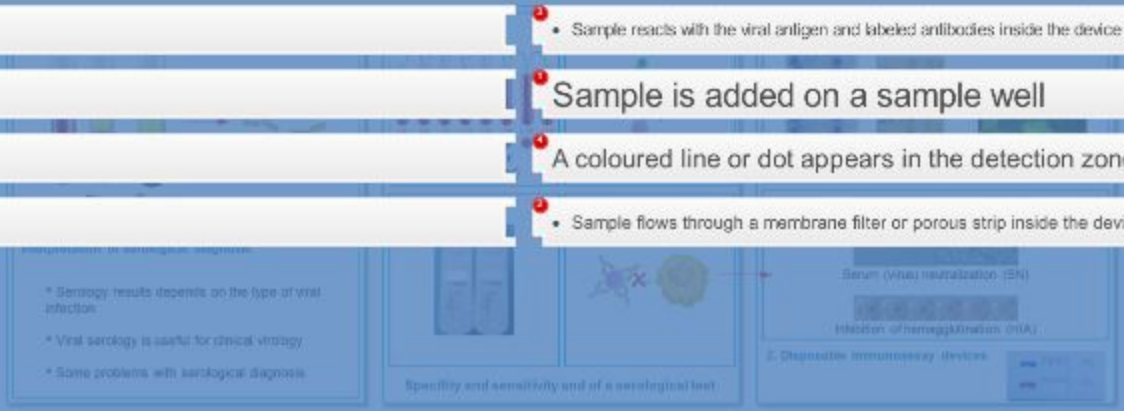

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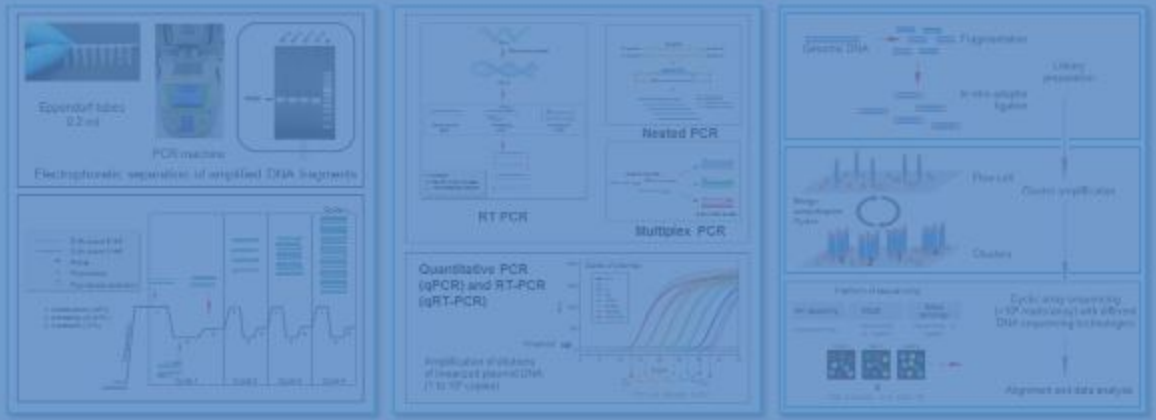

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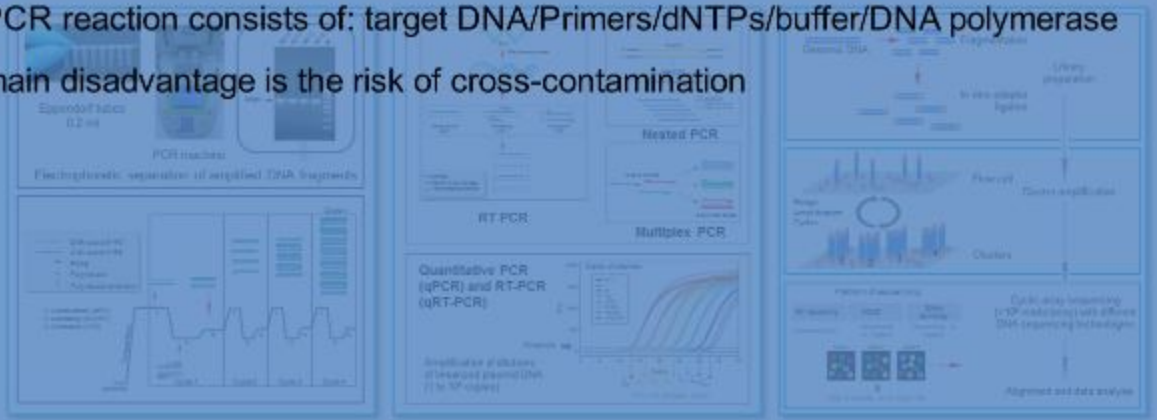

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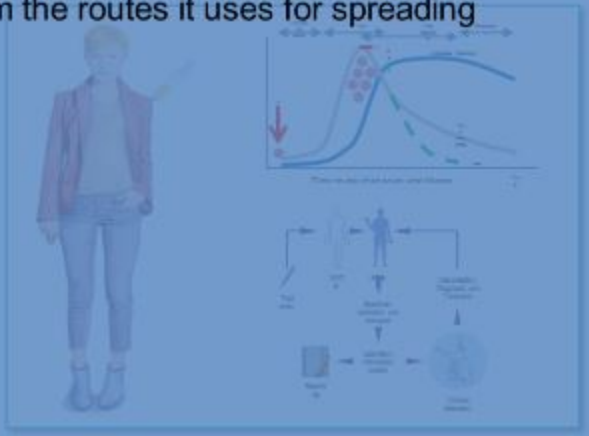

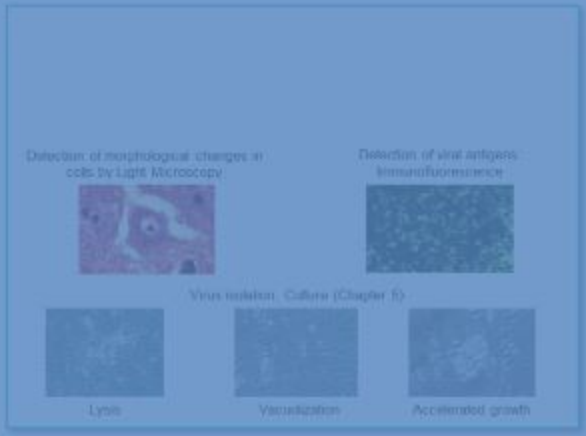

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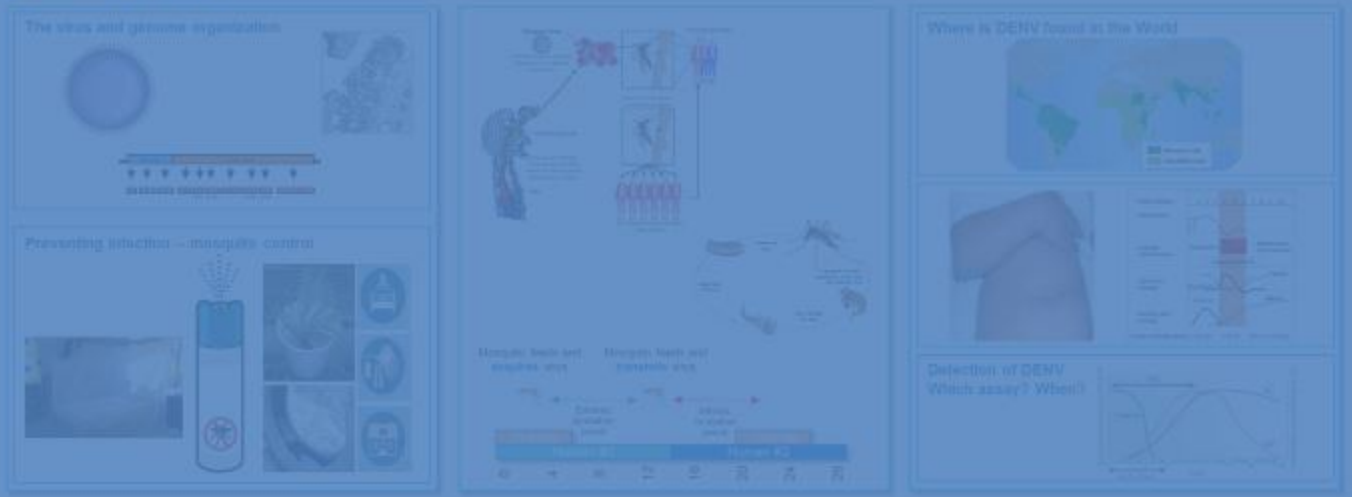

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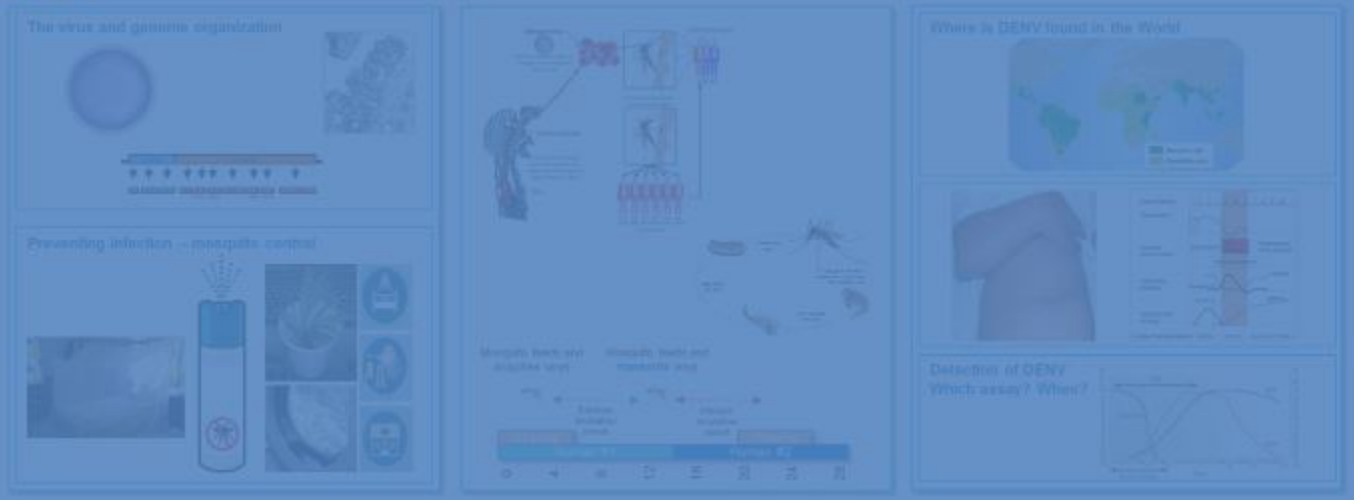

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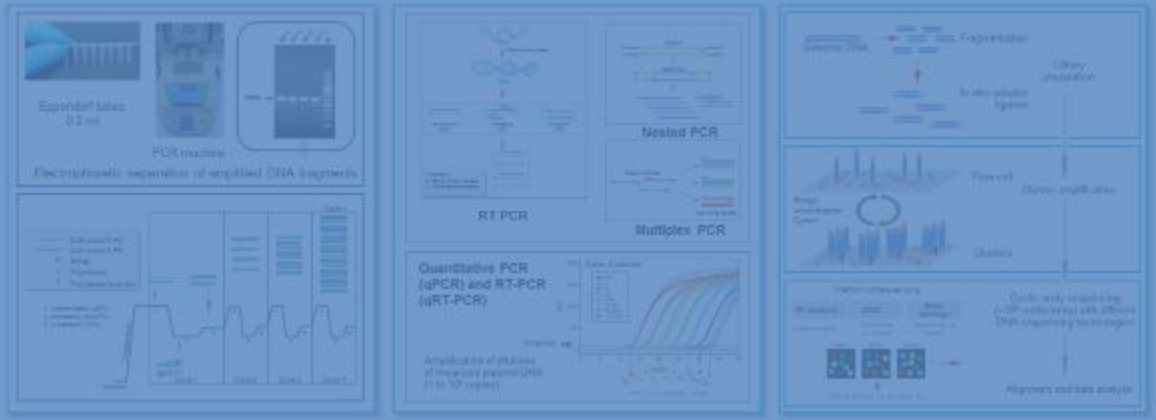

Ebolavirus can be spread from an infected person to another person by contact with sweat:

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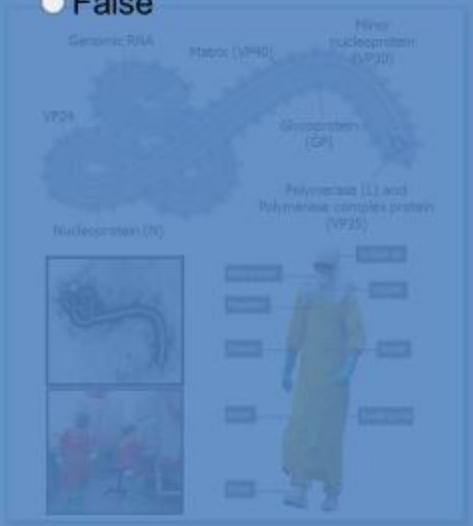

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The avian influenza strain is known as:

- H3N2
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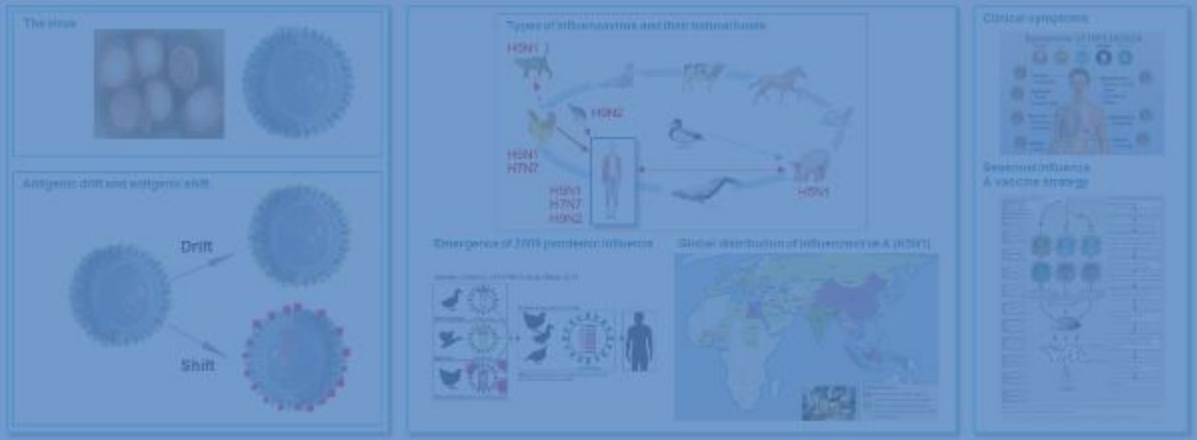

Fill in the blank: MERS is an acronym for: Middle East …… ……. Syndrome

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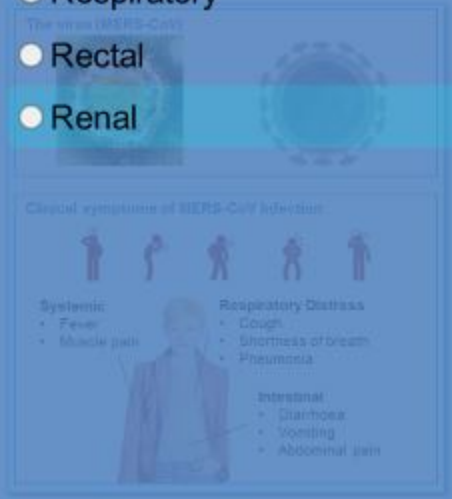

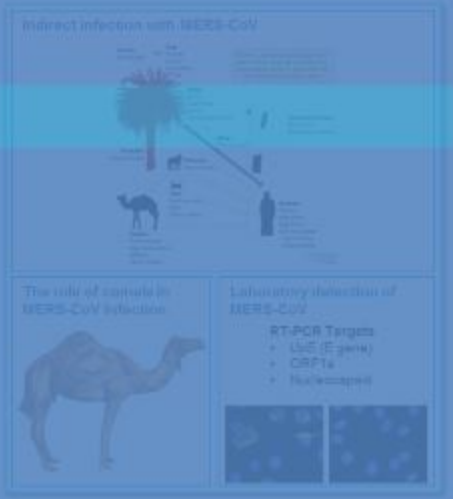

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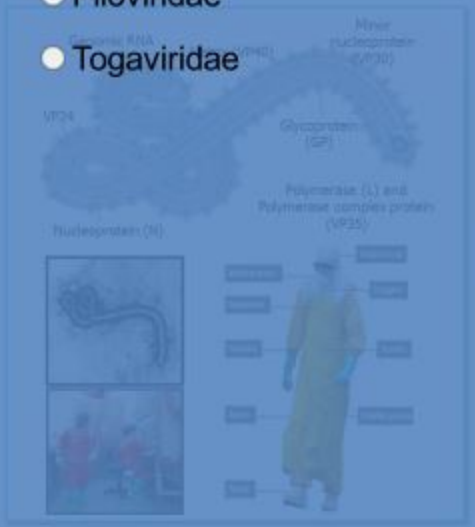

Which one of the following statements about PCR is wrong:

- A PCR program typically consists of 100-200 cycles
- The main advantages are its sensitivity and reproducibility
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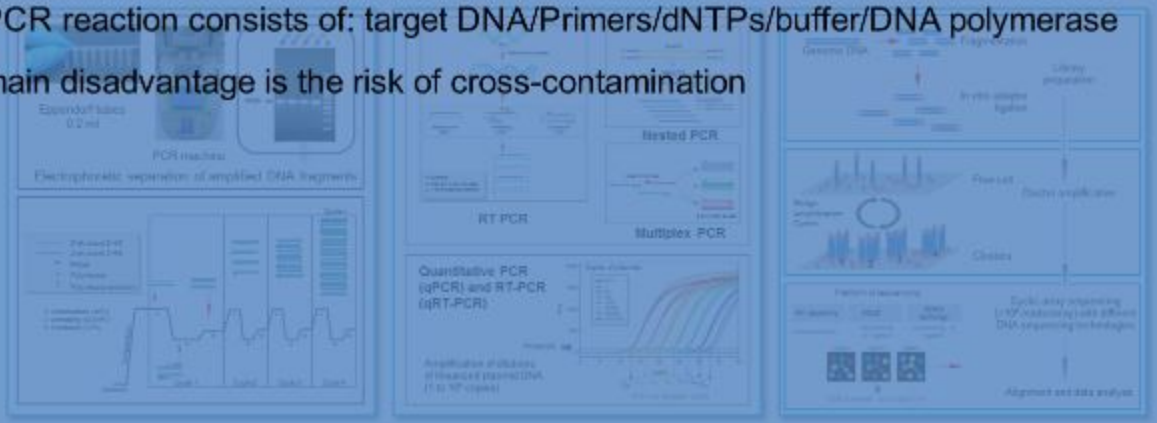

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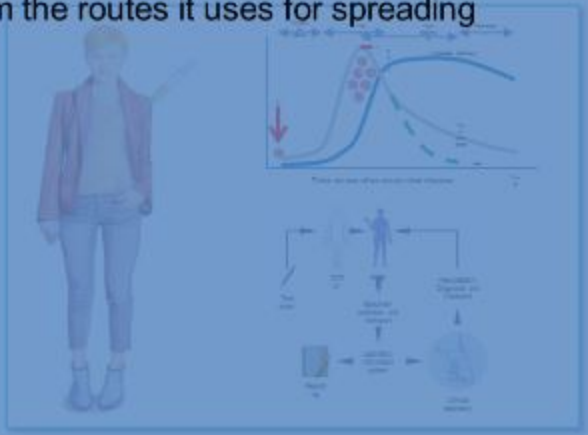

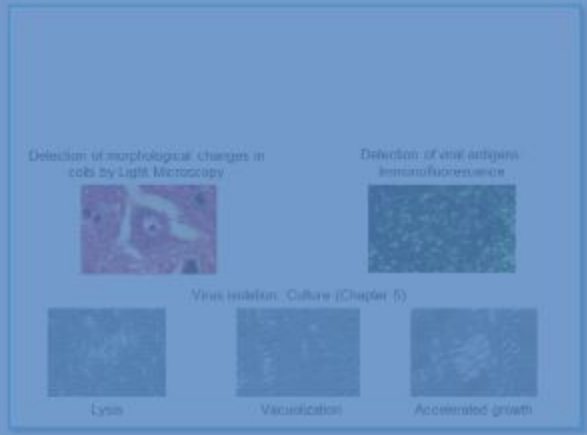

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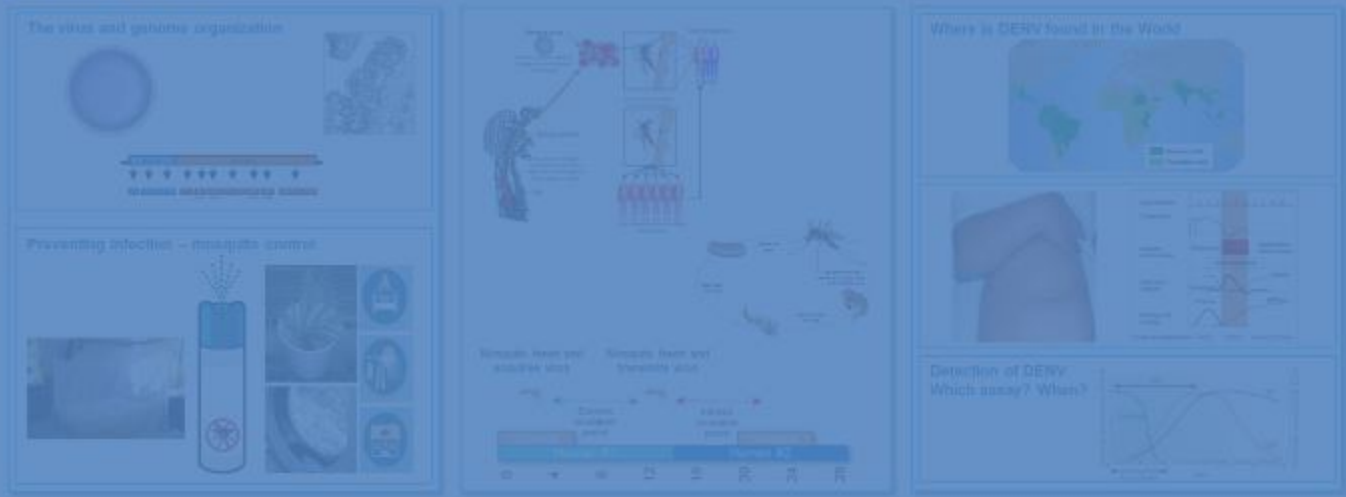

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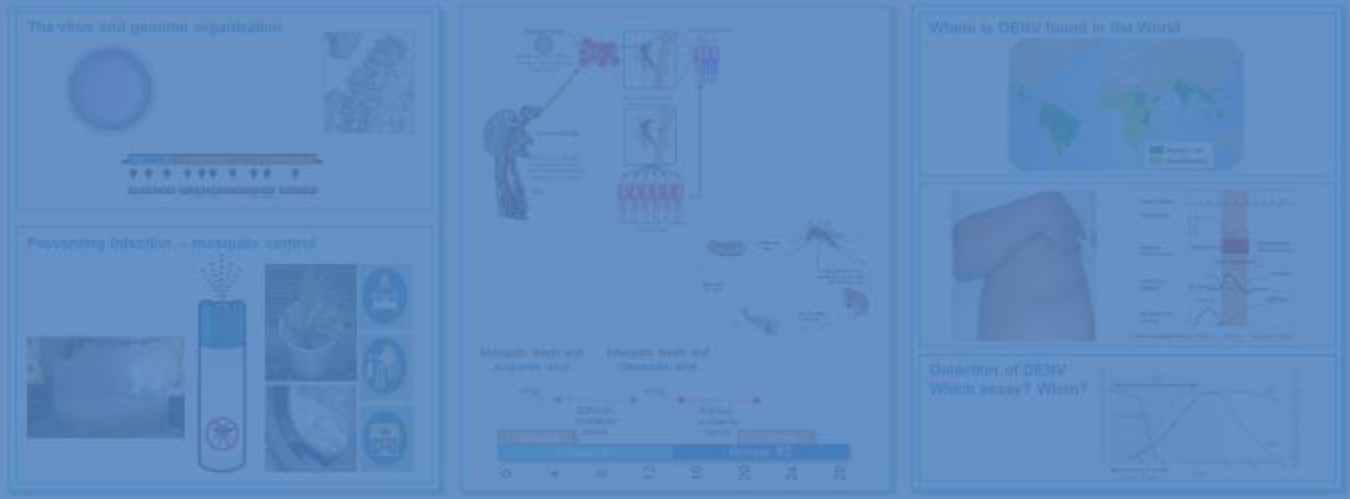

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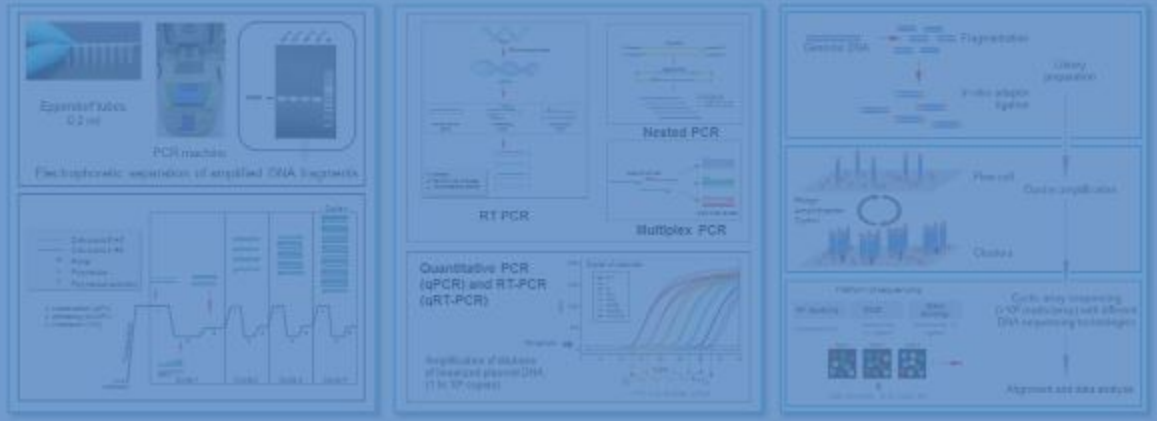

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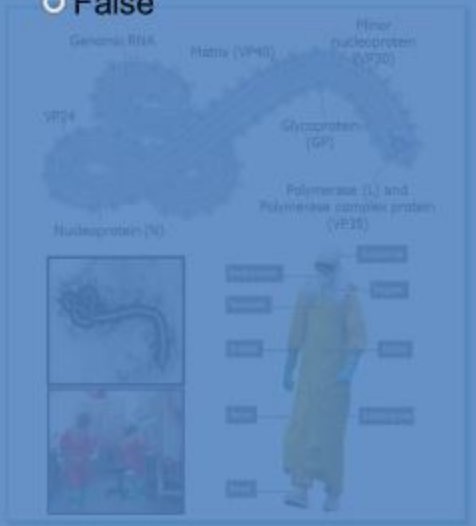

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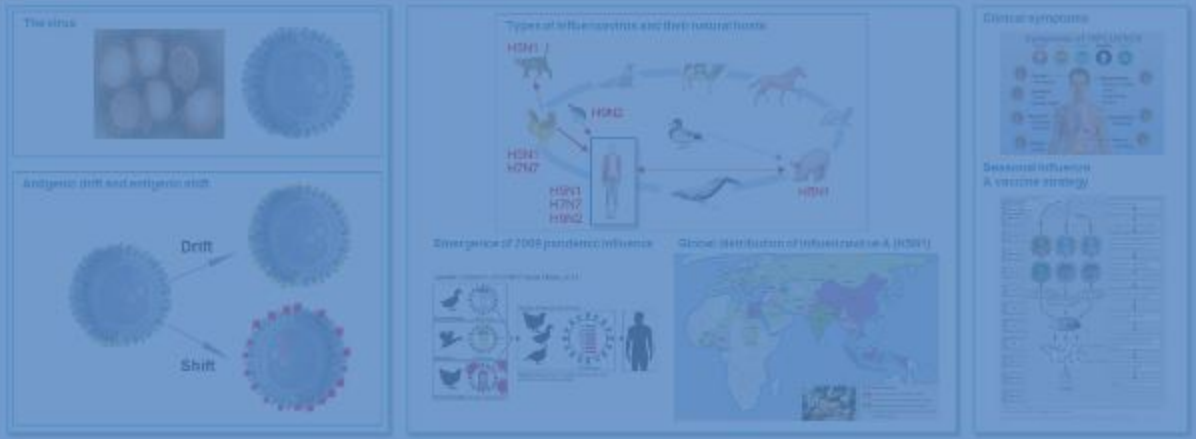

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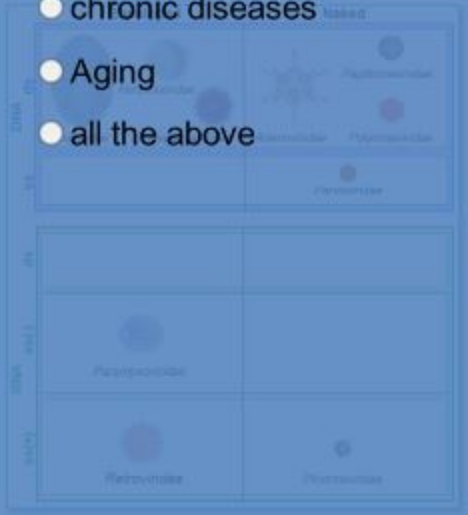

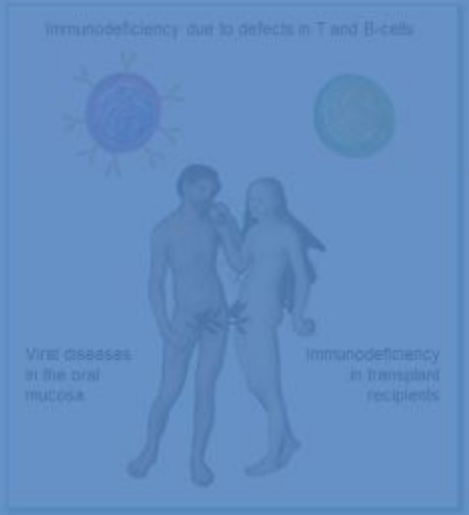

The cause of multiple sclerosis, an autoimmune neurodegenerative disease, is likely to be due to:

- activation of some endogenous retroviruses
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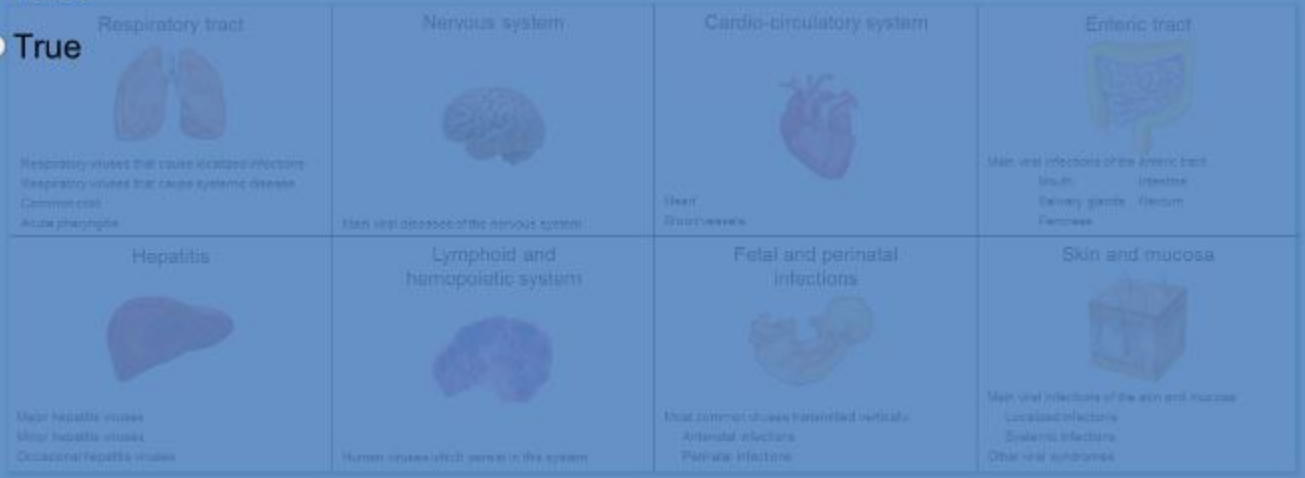

Lesions of the oral mucosa of immunocompromised patients may be caused by

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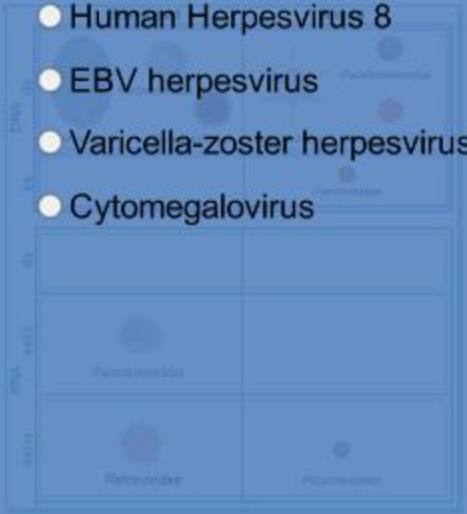

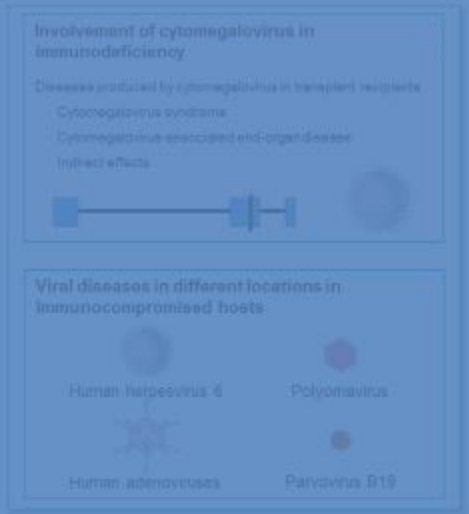

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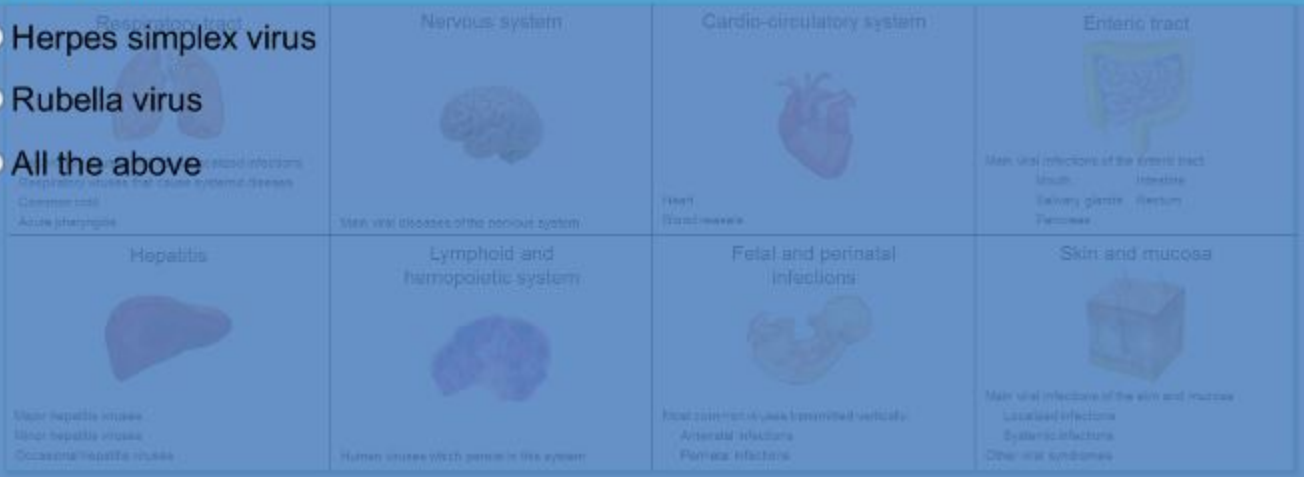

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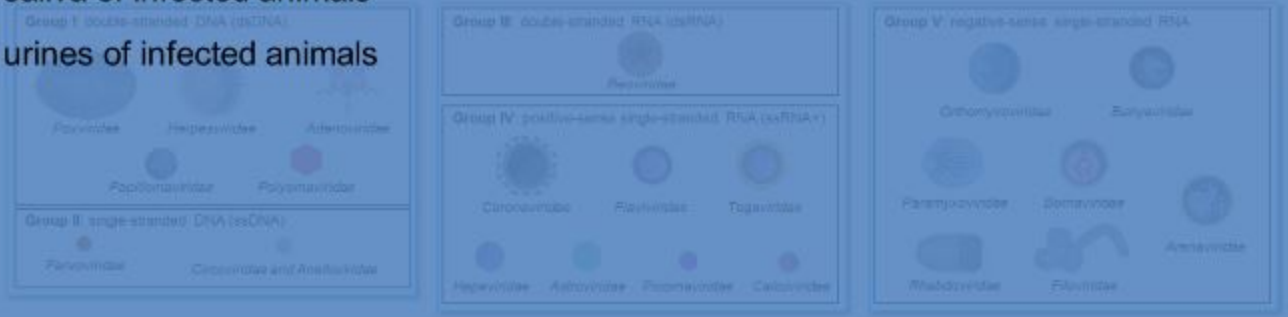

CCHFv is a member of the flaviviridae?

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Human hepatitis E virus is transmitted by:

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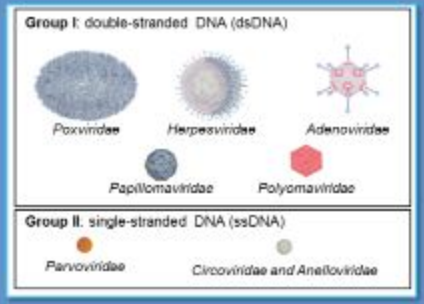

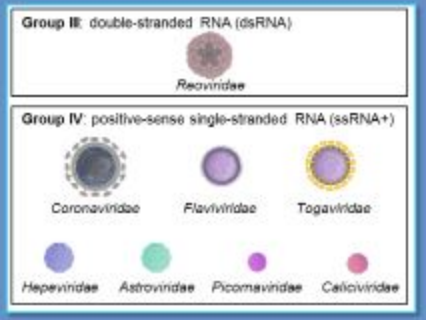

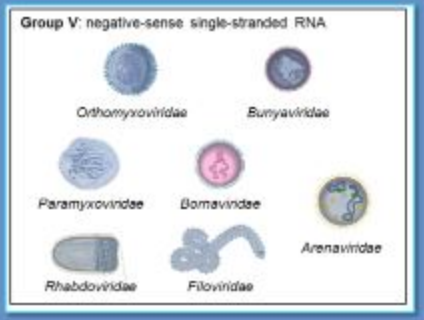

Fill in the blank: CCHF virus must be handled in a …… ….Laboratory

- Biosafety Level (BSL) 3
- Biosafety Level (BSL) 2
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"HIV infects preferentially _____ lymphocytes, monocytes/macrophages and dendritic cells, that are essential for immune defense". Fill in the blank:

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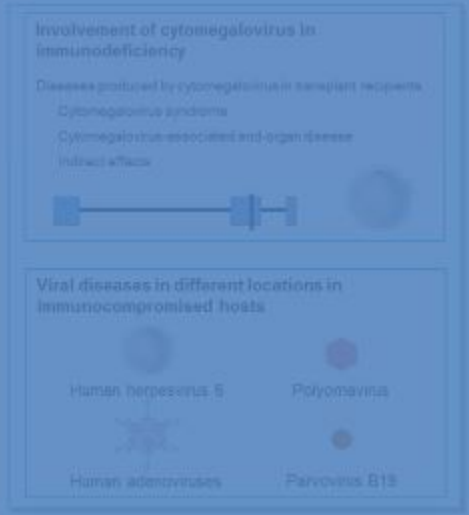

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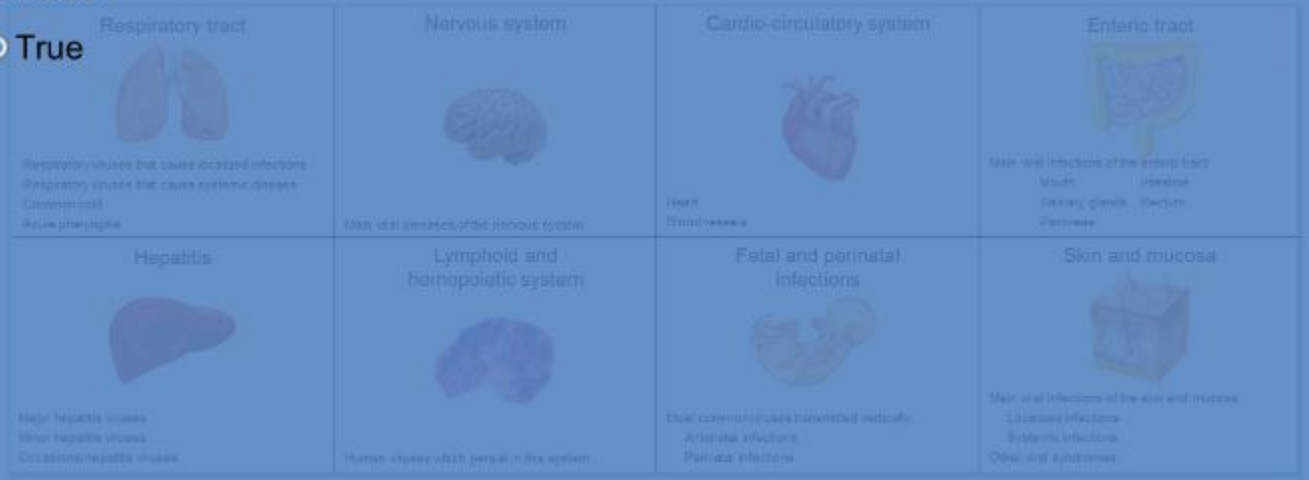

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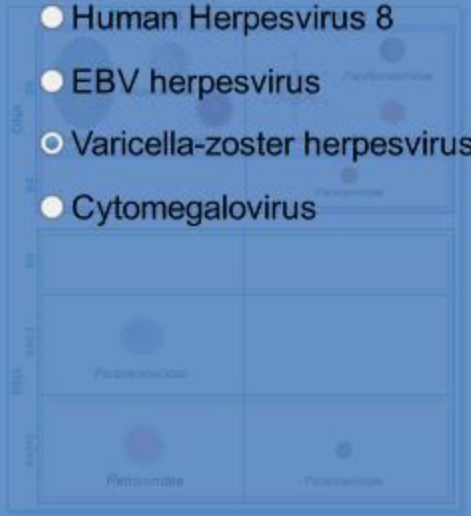

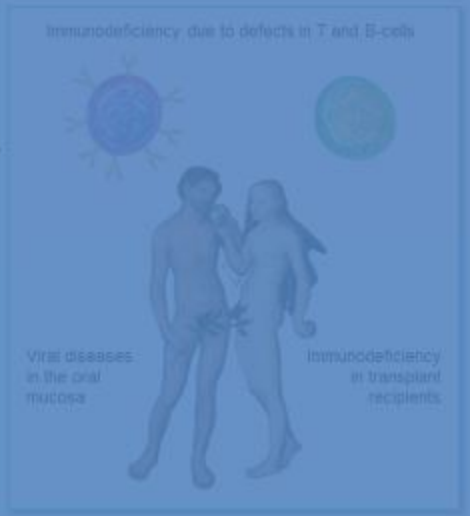

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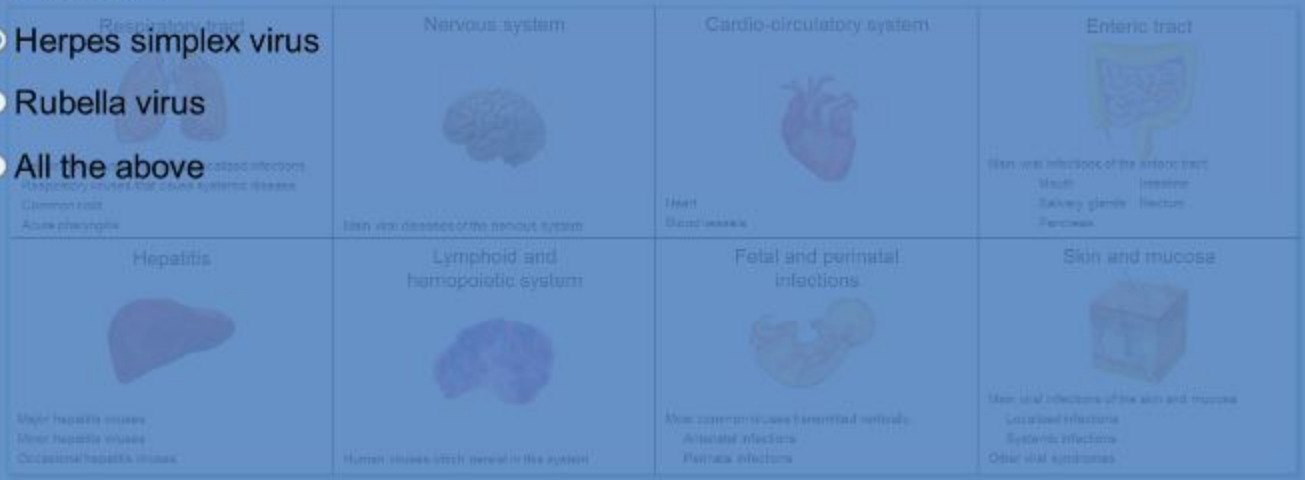

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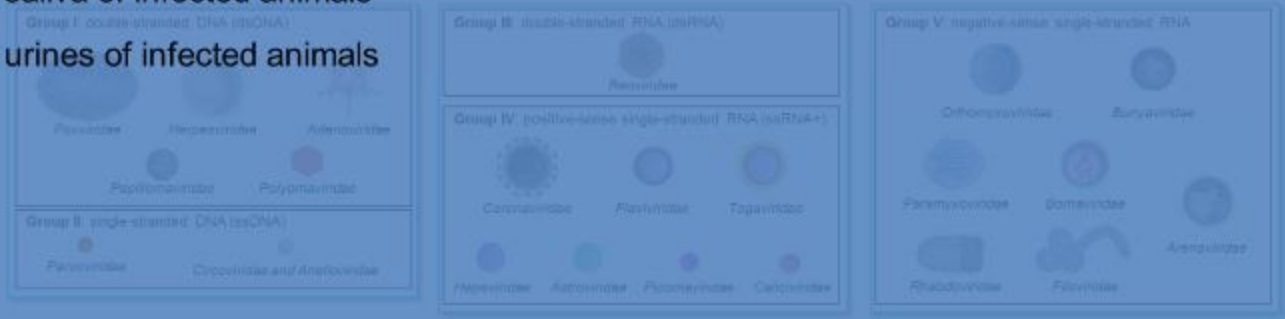

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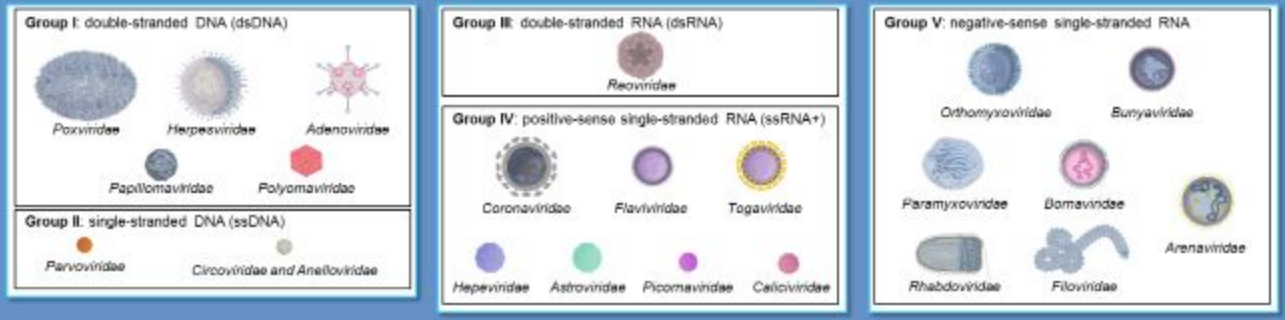

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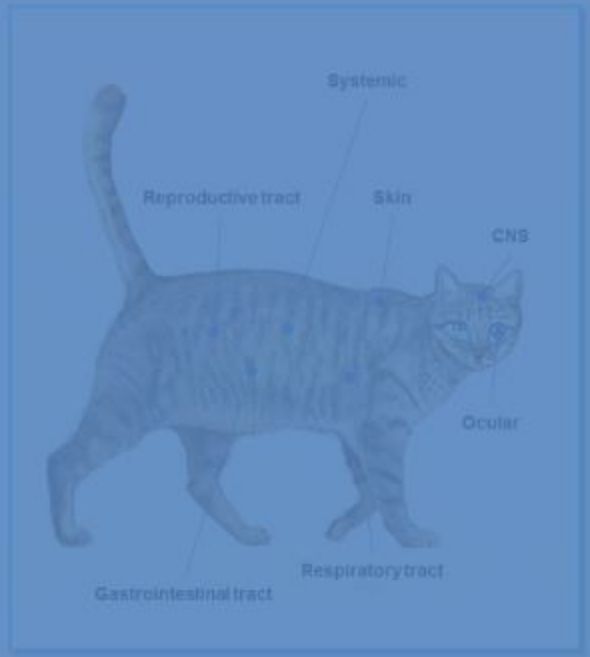
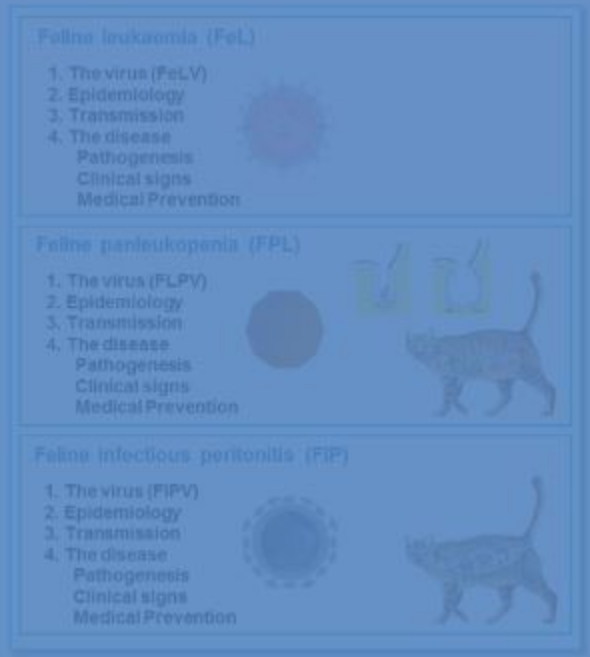
Feline Panleukopenia virus (FPL) is a non-enveloped, icosaedral, small and very stable virus classified into the _____family viruses Herpesviridae

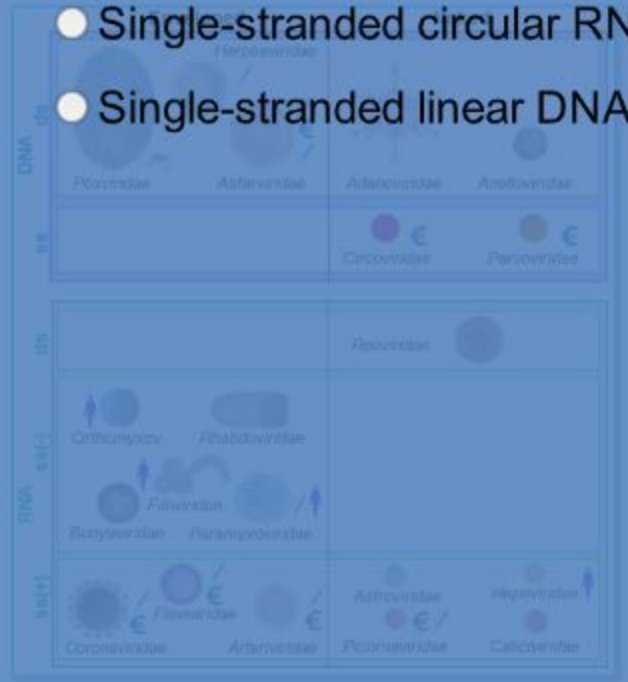
- Parvoviridae
- Coronaviridae
- Reoviridae

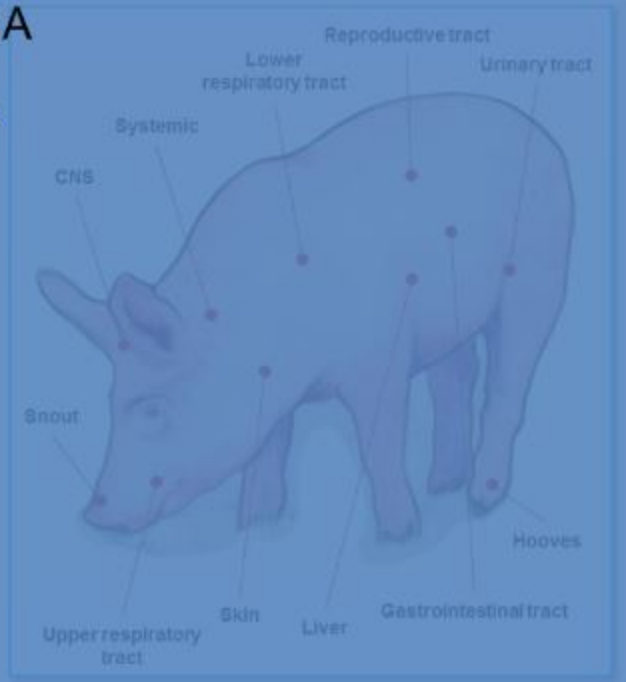




What type of genome do circovirus have?

- Double-stranded circular DNA
- Single-stranded circular DNA
- Single-stranded circular RNA
- Single-stranded linear DNA





African Swine Fever (ASF)

1. The virus (ASFV)
2. Epidemiology
3. Transmission
4. The disease
   - Pathogenesis
   - Clinical signs
   - Medical Prevention

Porcine circovirosis

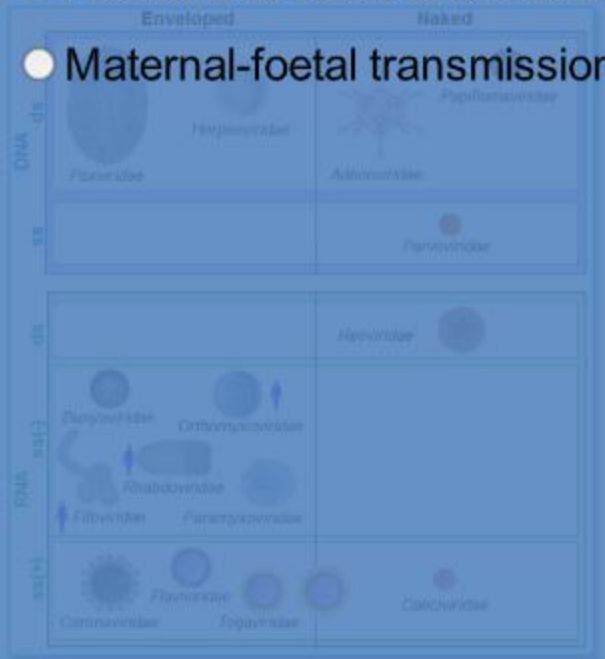
1. The virus (PCV-2)
2. Epidemiology
3. Transmission
4. The disease
   - Pathogenesis
   - Clinical signs
   - Medical Prevention

Porcine respiratory-reproductive syndrome (PRRS)

1. The agent (PRRSV)
2. Epidemiology
3. Transmission
4. The disease
   - Pathogenesis
   - Clinical signs
   - Medical Prevention

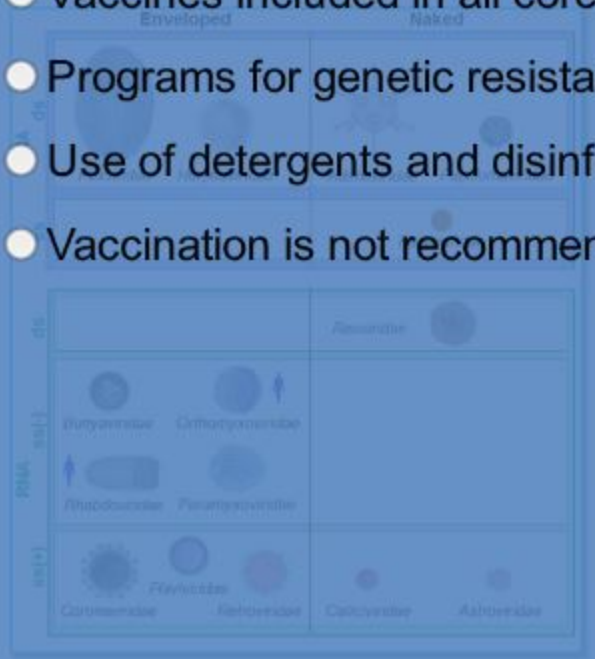
The transmission of Canine Parvovirus (CP) is by:

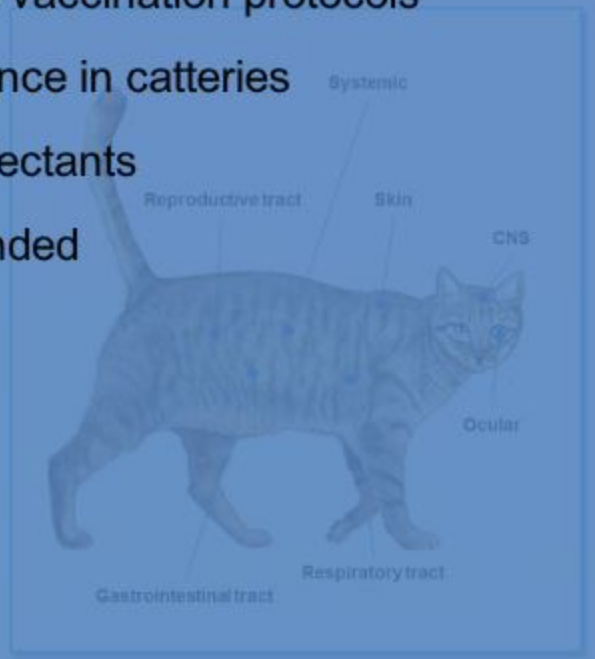
- Infected aerosol droplets
- Faecal-oral route
- Faecal-oral route and Maternal-foetal transmission
- Maternal-foetal transmission

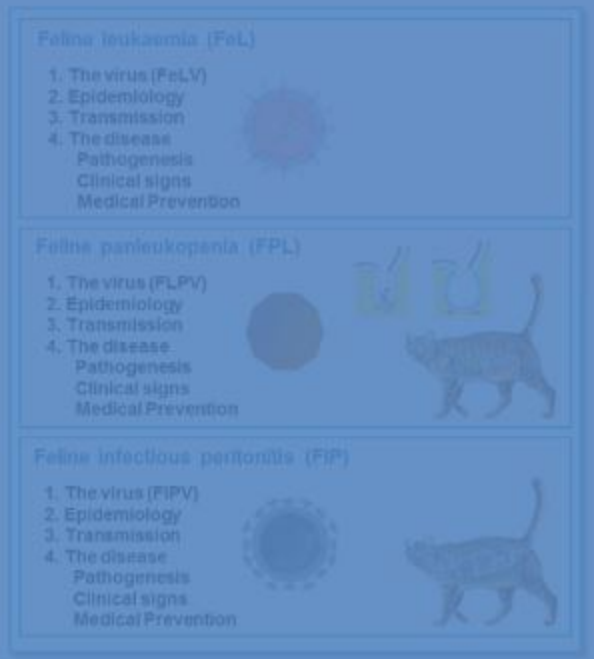


Feline panleukopenia (also called feline "distemper,") is a highly contagious viral disease of cats; the medical prevention consist:

- Vaccines included in all core vaccination protocols
- Programs for genetic resistance in catteries
- Use of detergents and disinfectants
- Vaccination is not recommended

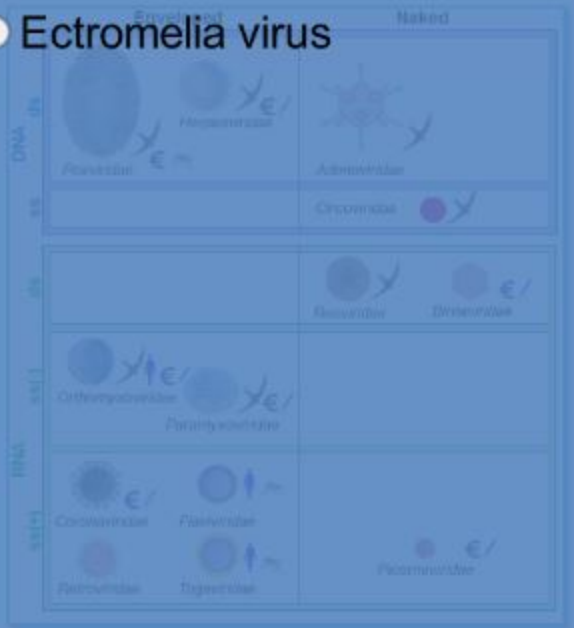


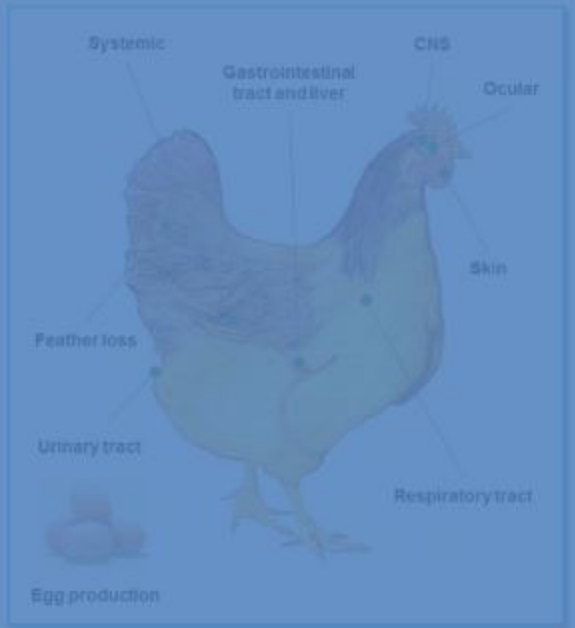




Which poxvirus may affect rabbits and rodents?

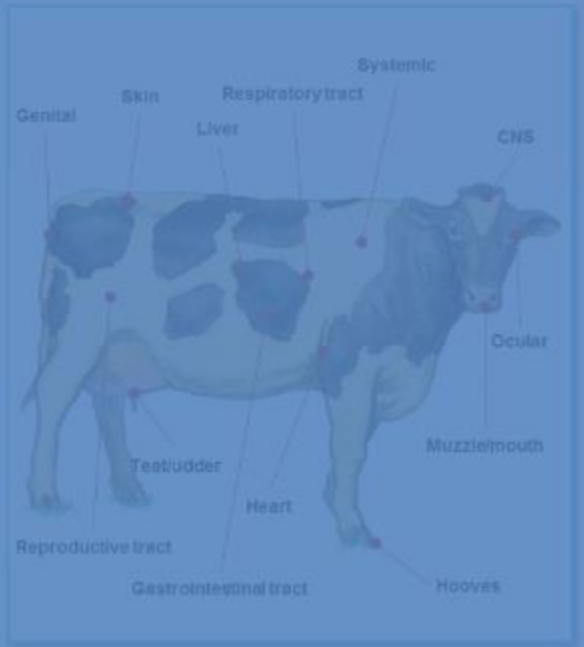
- Myxoma virus
- All the other options
- Rabbit (Shope) Fibroma virus
- Ectromelia virus





Which of these animals is not susceptible to foot and mouth disease virus?

- Cattle
- Sheep and goat
- Horse
- Pig



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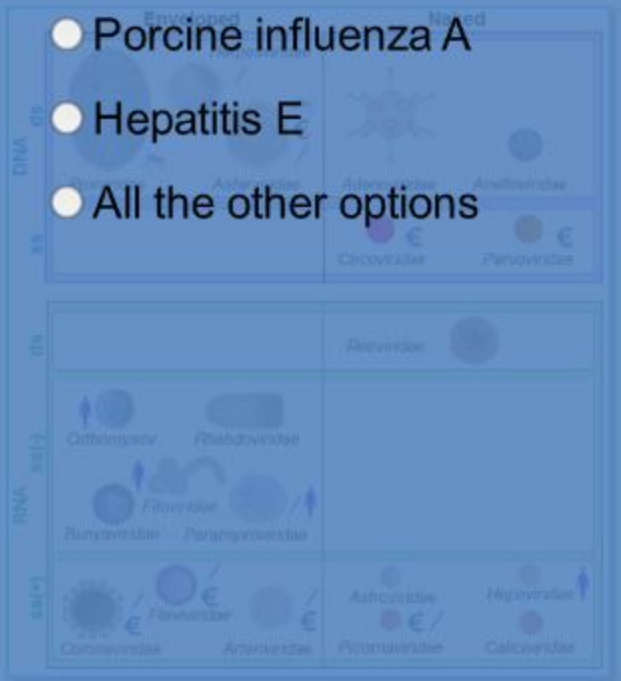

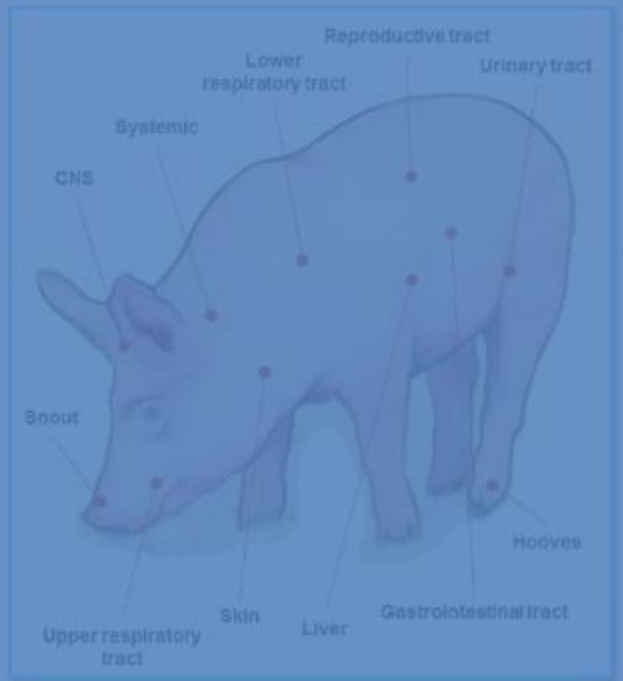

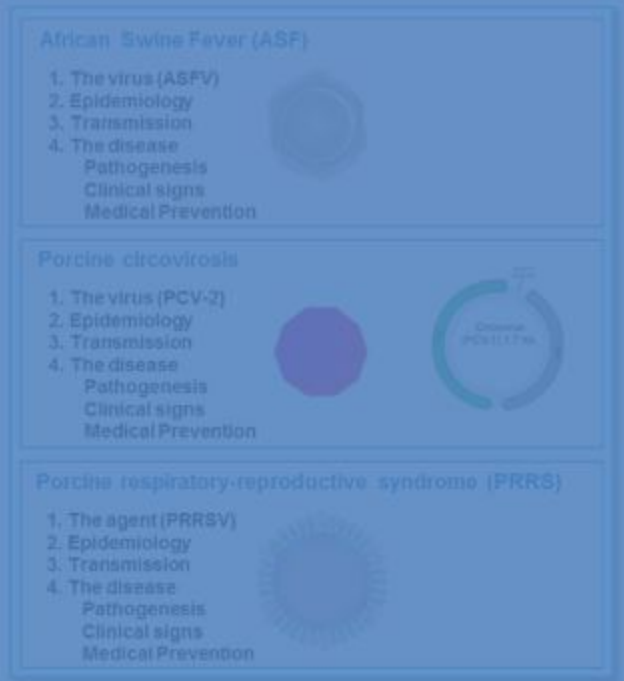

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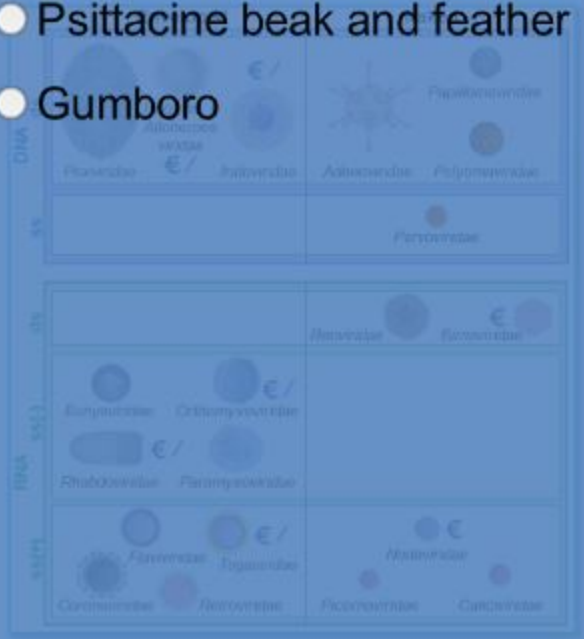

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- False
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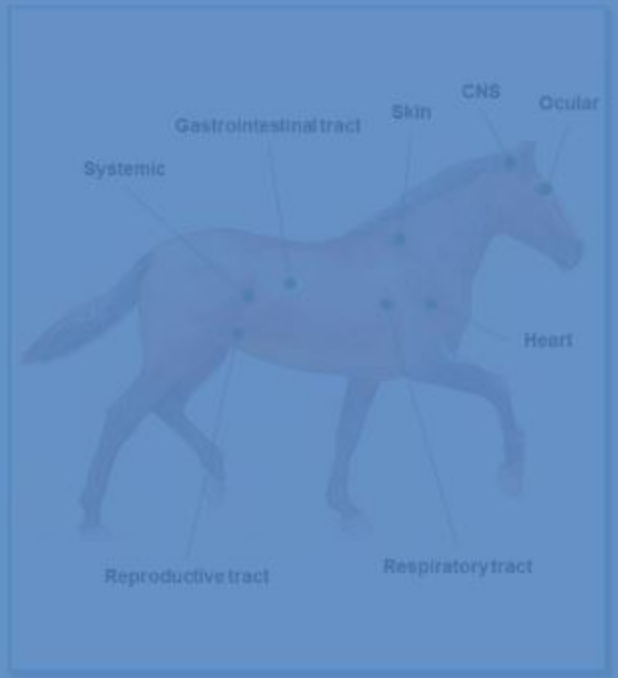

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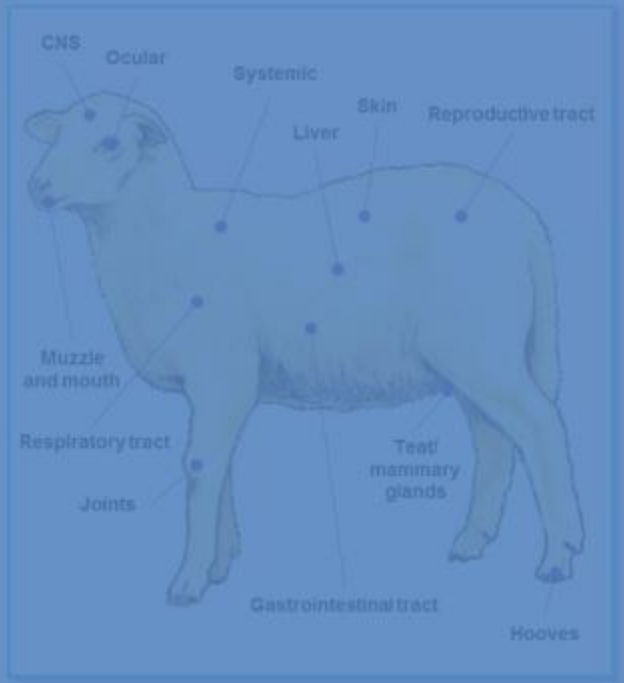
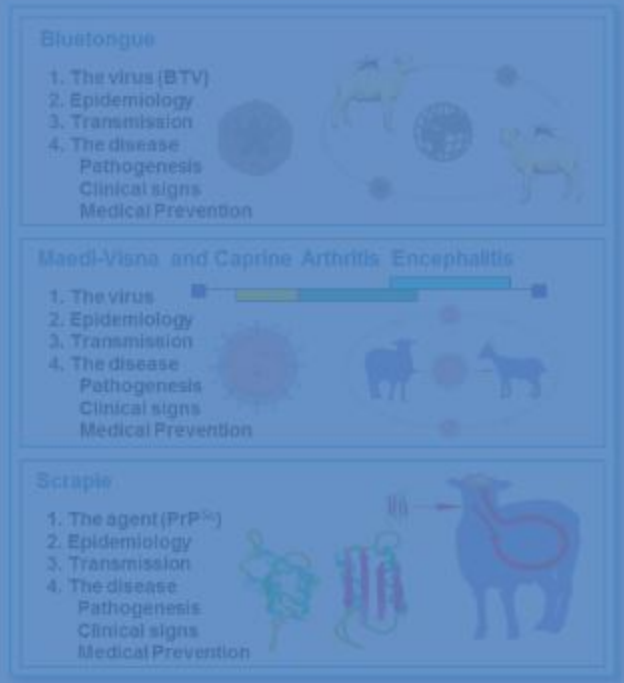
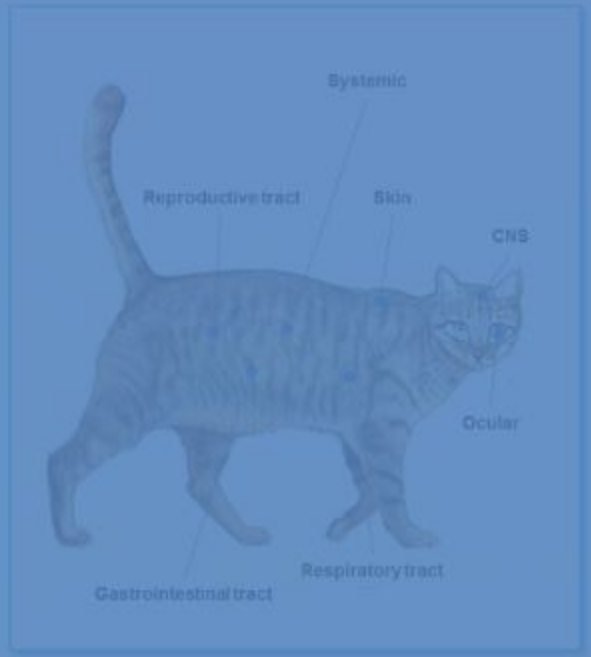
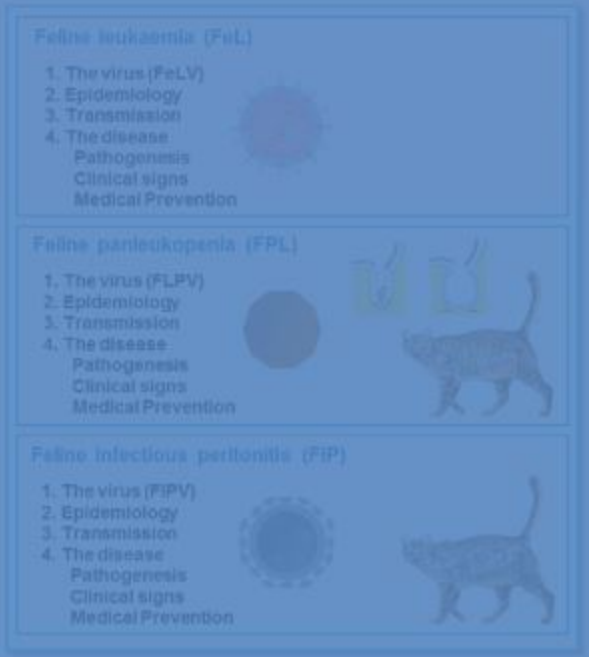




Feline Panleukopenia virus (FPL) is a non-enveloped, icosaedral, small and very stable virus classified into the _____family viruses Herpesviridae

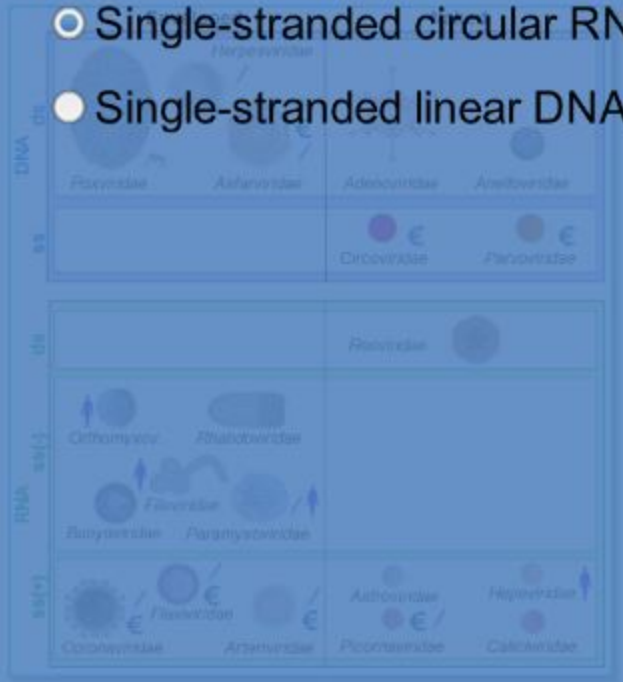
- ✓ Parvoviridae
- Coronaviridae
- Reoviridae

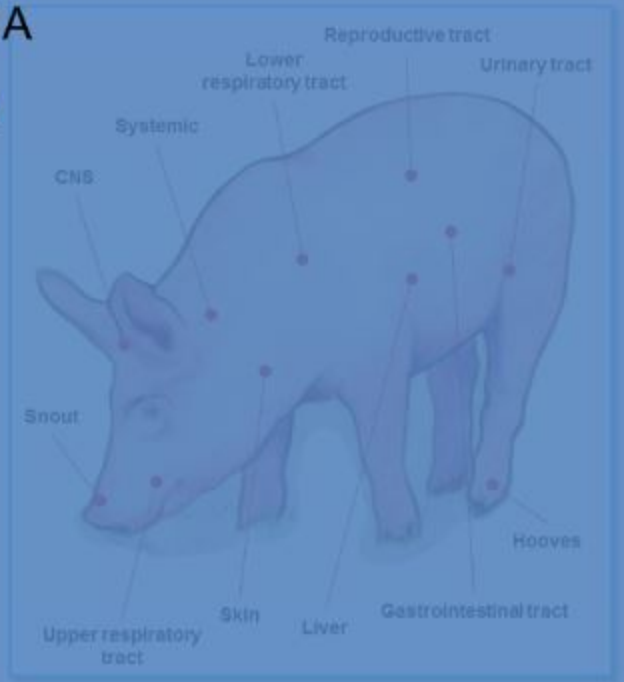


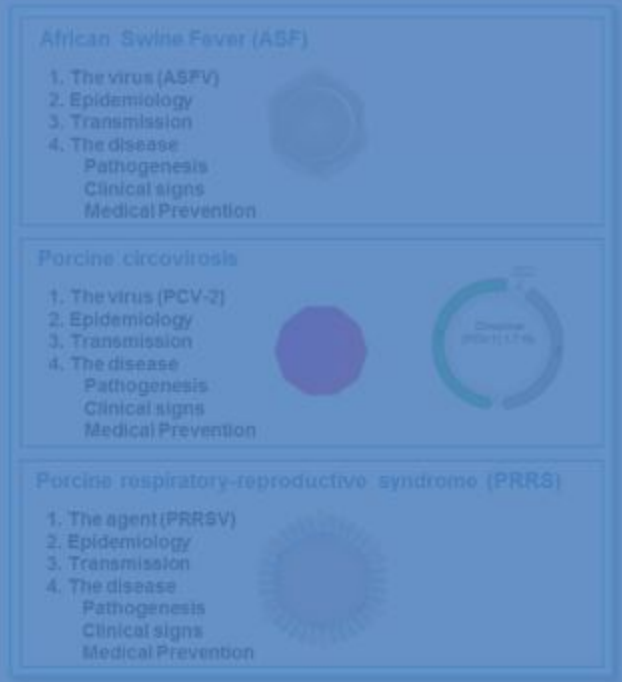


What type of genome do circovirus have?

- Double-stranded circular DNA
- ✓ Single-stranded circular DNA
- Single-stranded circular RNA
- Single-stranded linear DNA





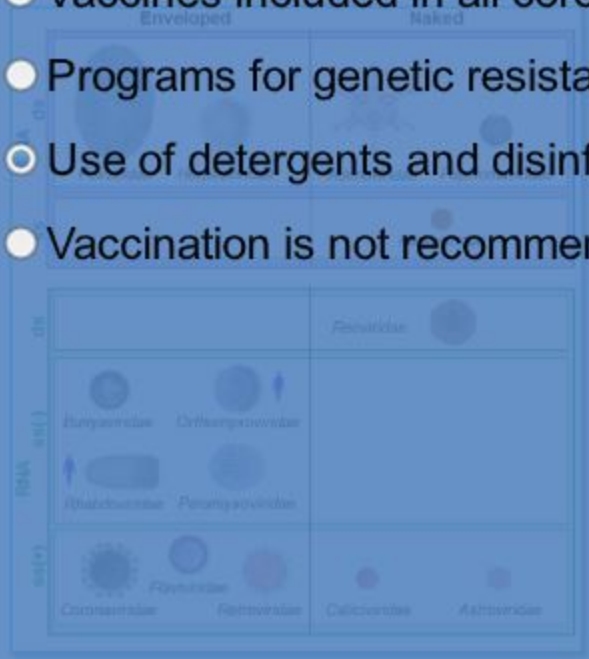


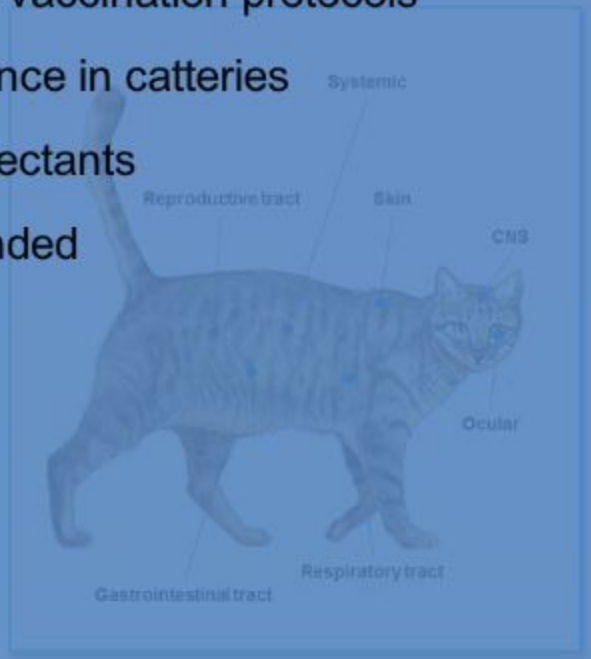
The transmission of Canine Parvovirus (CP) is by:

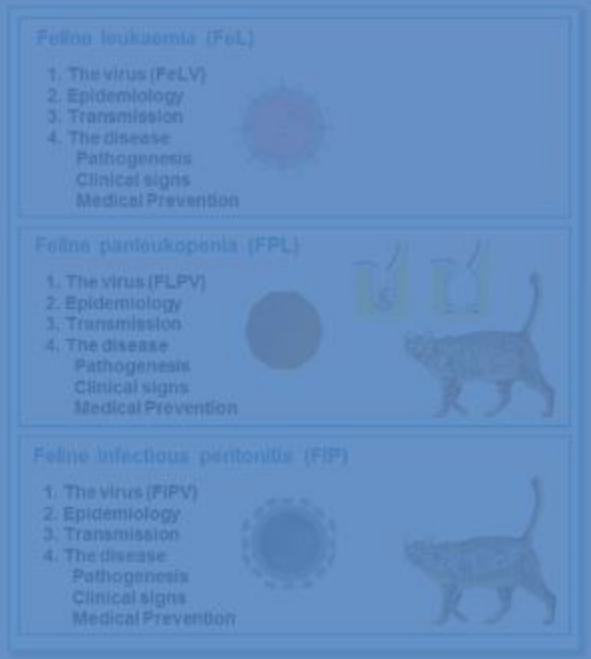
- Infected aerosol droplets
- Faecal-oral route
- ✓ Faecal-oral route and Maternal-foetal transmission
- Maternal-foetal transmission

Feline panleukopenia (also called feline "distemper,") is a highly contagious viral disease of cats; the medical prevention consist:

- Vaccines included in all core vaccination protocols
- Programs for genetic resistance in catteries
- Use of detergents and disinfectants
- Vaccination is not recommended

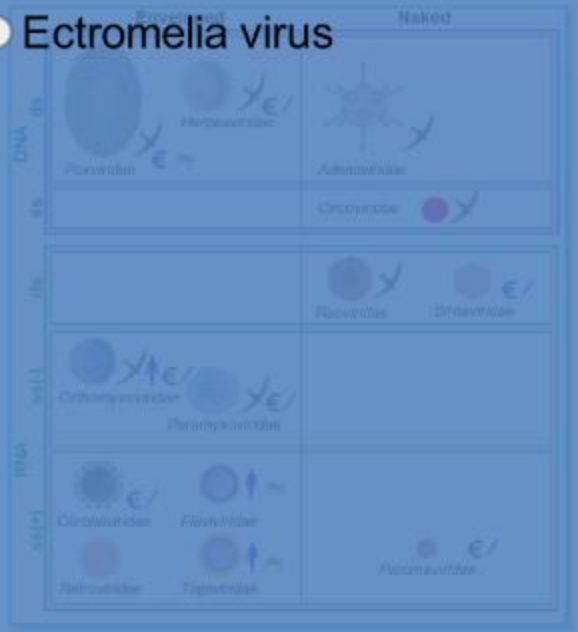


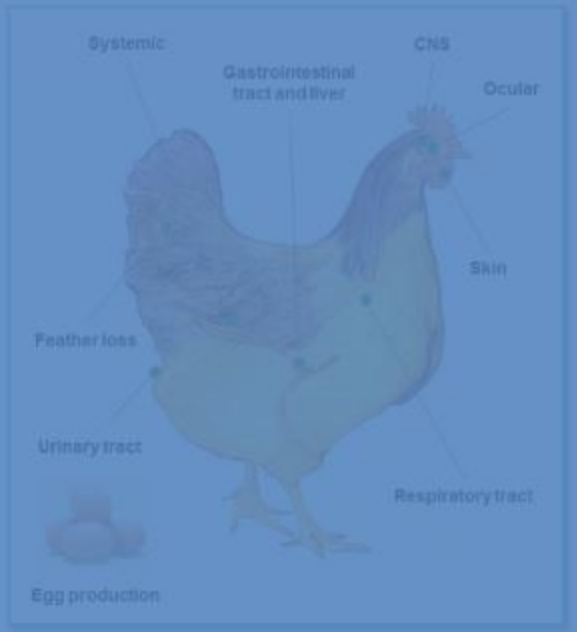




Which poxvirus may affect rabbits and rodents?

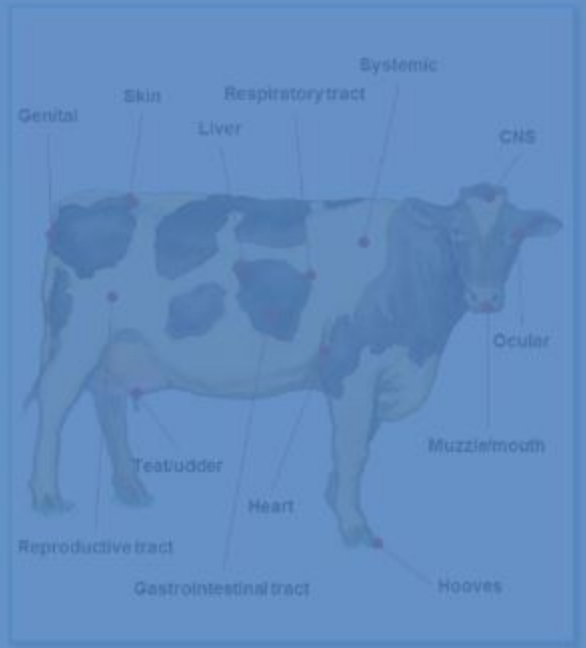
- Myxoma virus
- ✓ All the other options
- Rabbit (Shope) Fibroma virus
- Ectromelia virus





Which of these animals is not susceptible to foot and mouth disease virus?

- Cattle
- Sheep and goat
- ✓ Horse
- Pig



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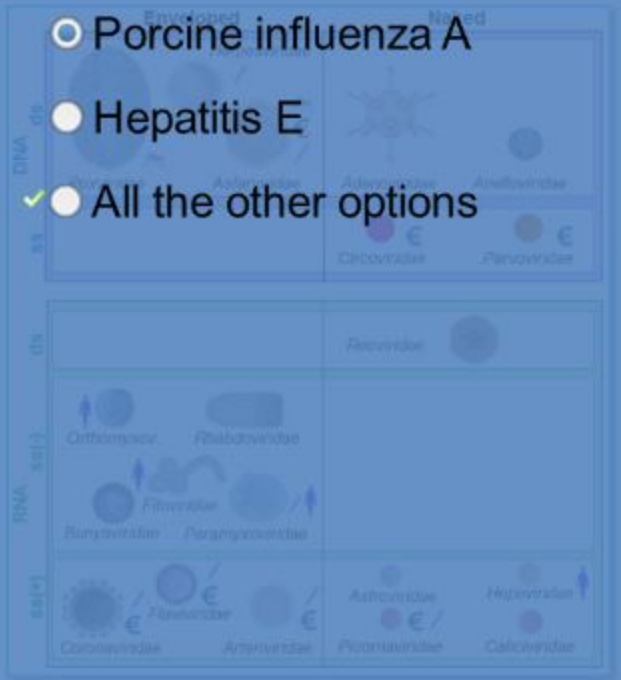

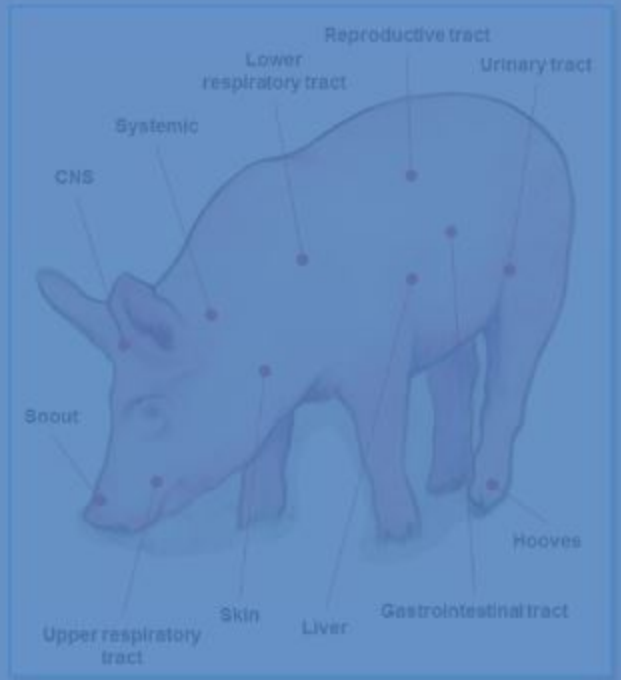

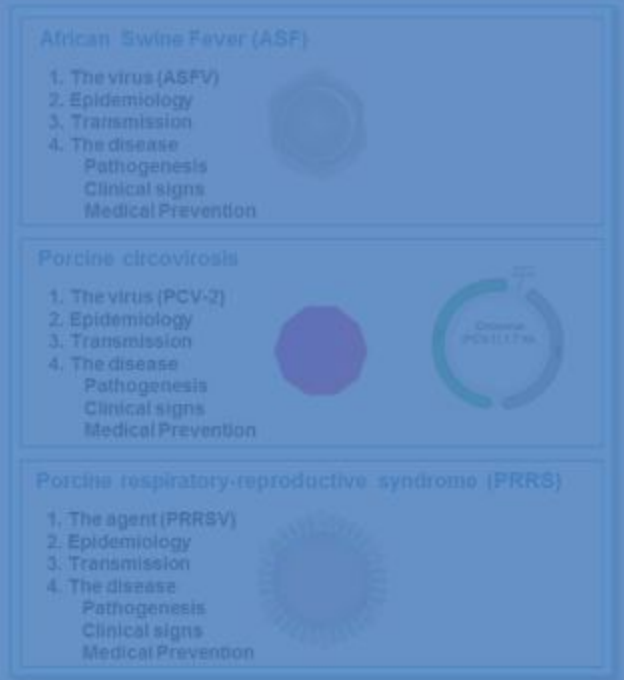

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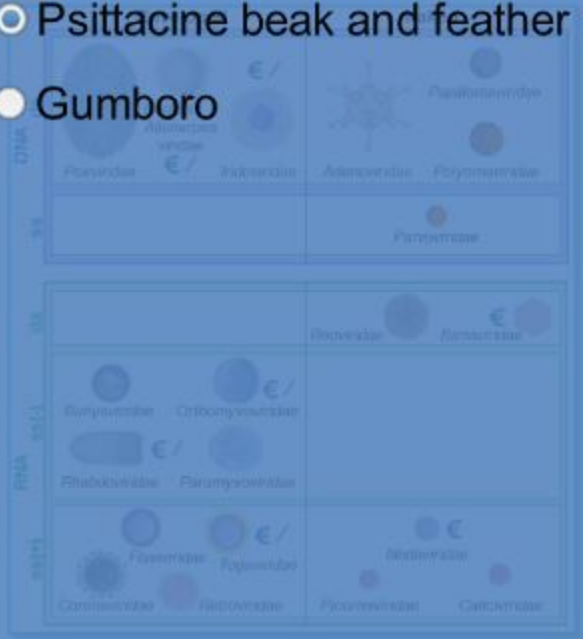

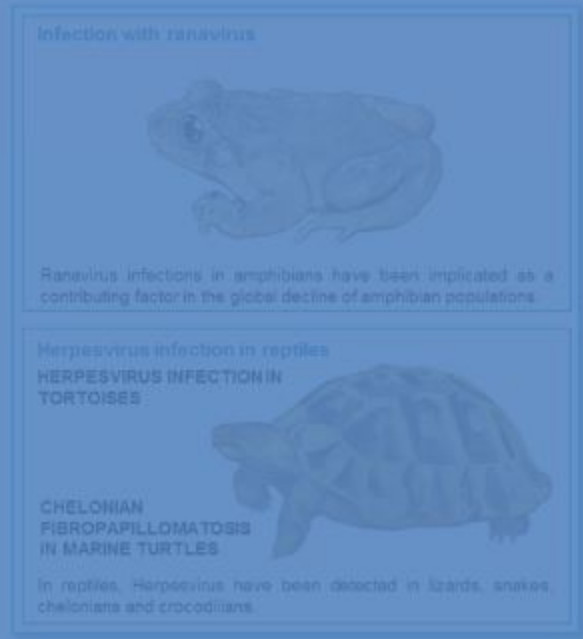

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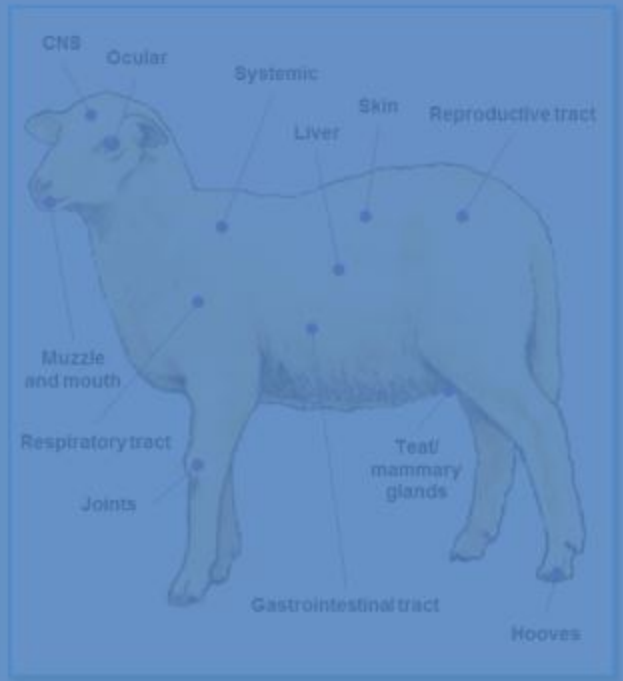

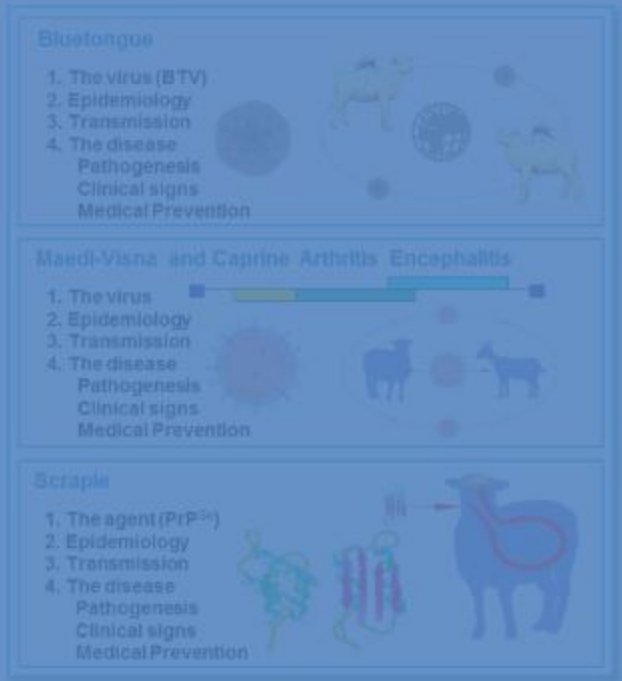

Infection from mother plants to offspring (called vertical transmission) is connected with:

- All answersare correct
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- Using natural plant organs (bulbs, cuttings) from infected plants for vegetative propagation
- Using infected seeds

Transmission of Tobacco mosaic virus by seeds is connected with:

- Presence of TMV virions in infected pollen
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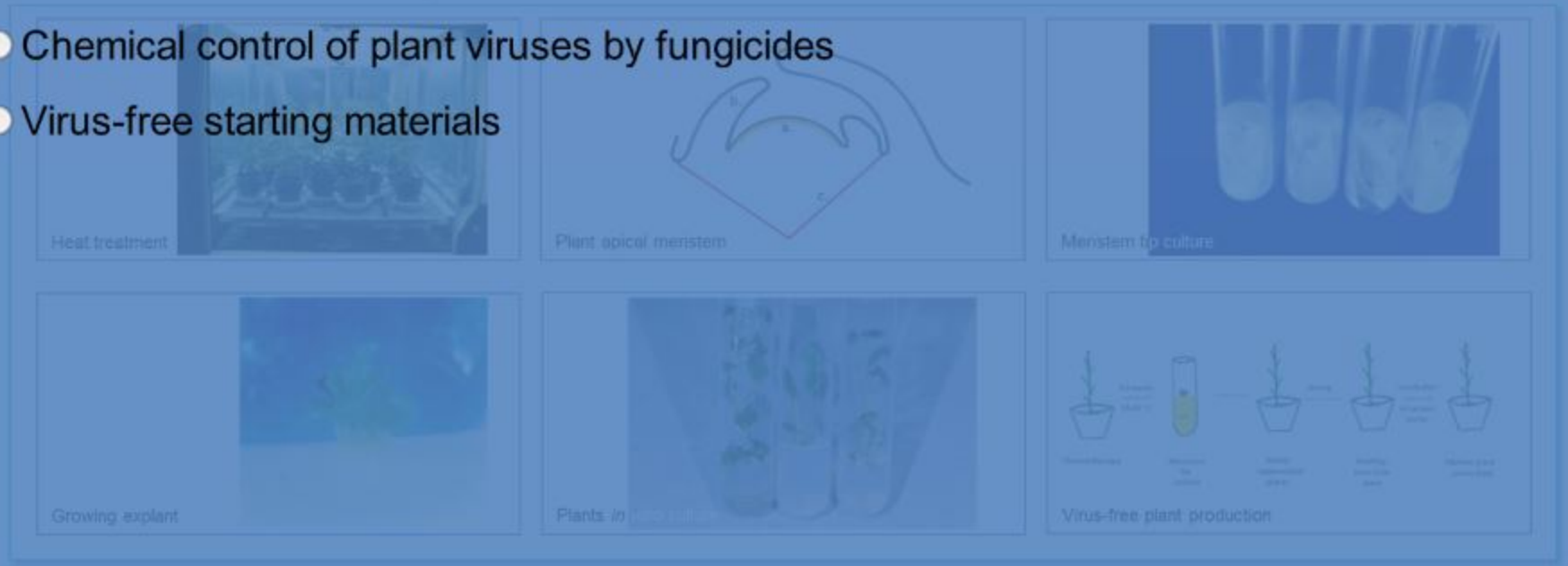

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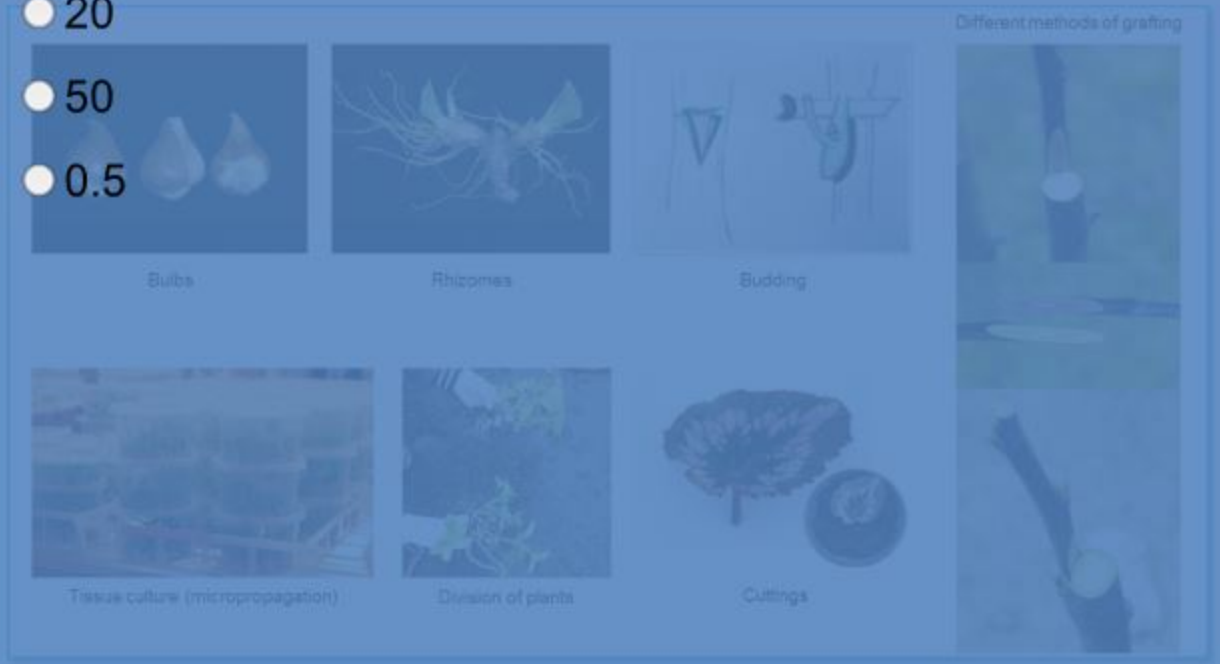

What may be encoded during the replication of +ssRNA viruses?

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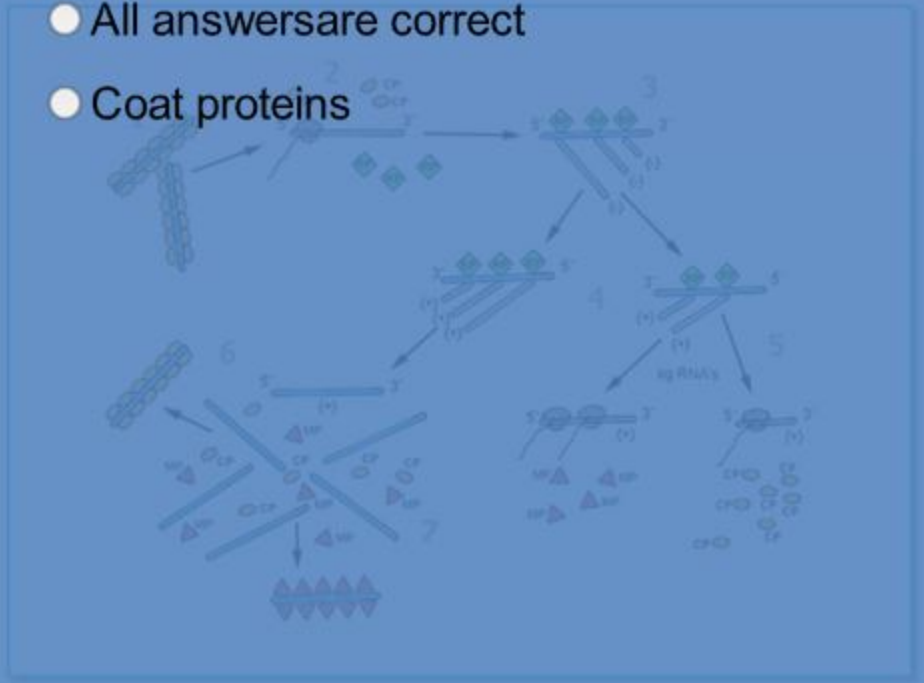
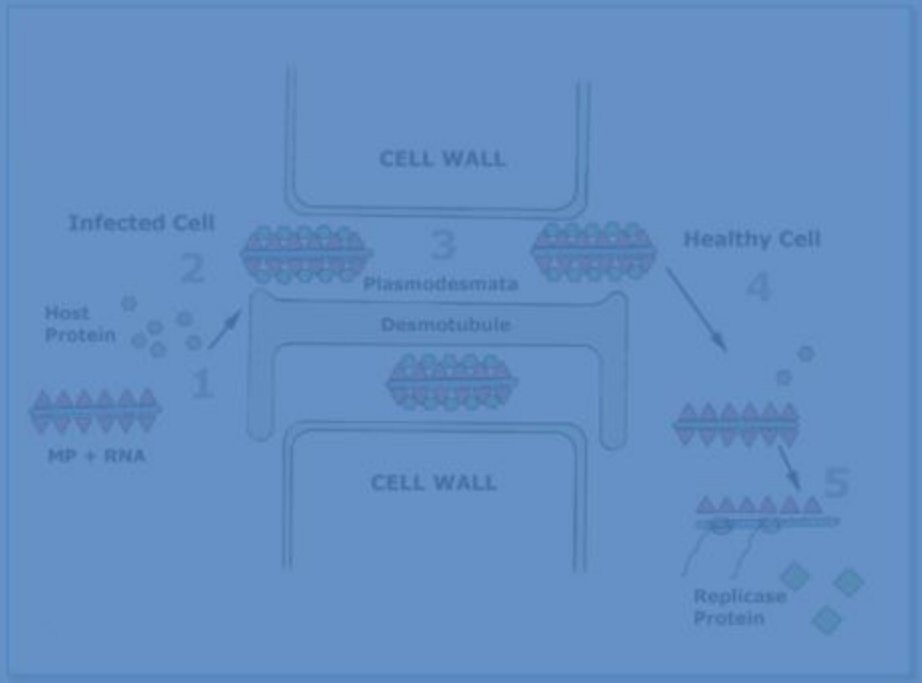
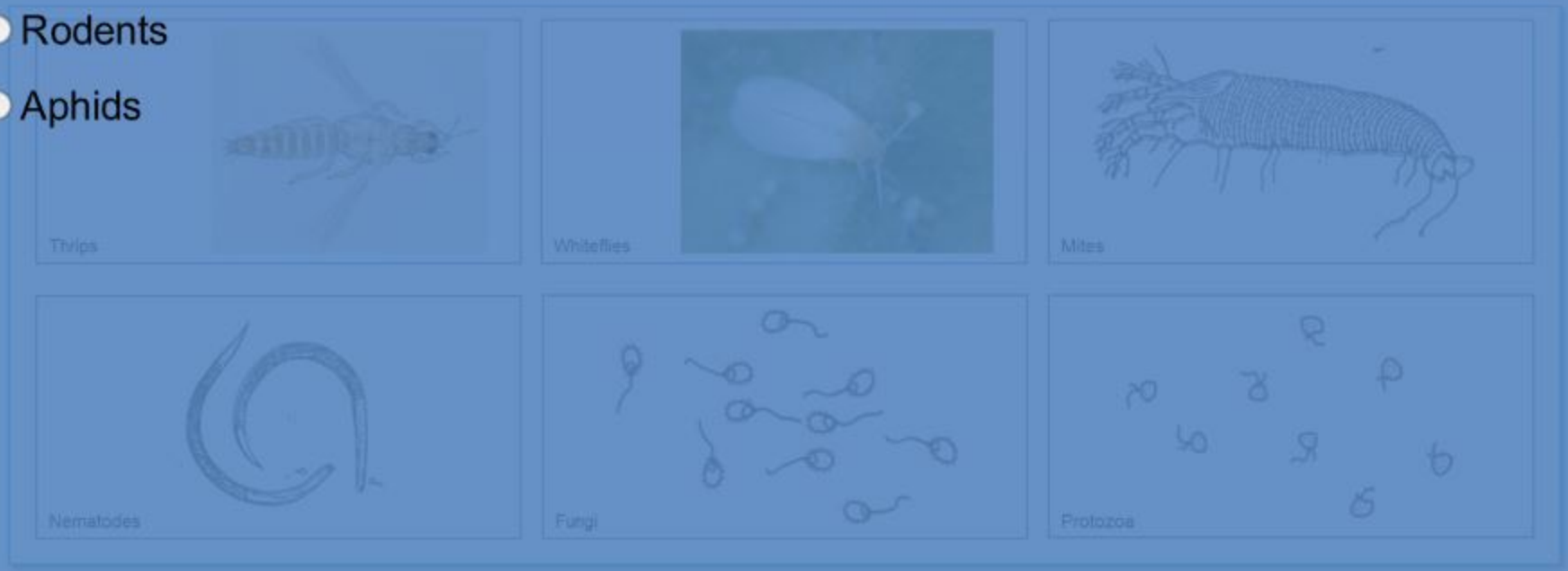




Plant viruses could be transmitted long distances by:

- Birds
- Fishes
- Rodents
- Aphids



Tomato spotted wilt virus:

- Acquisition of virus is possible only by the first larval instar
- Is transmitted by the trips
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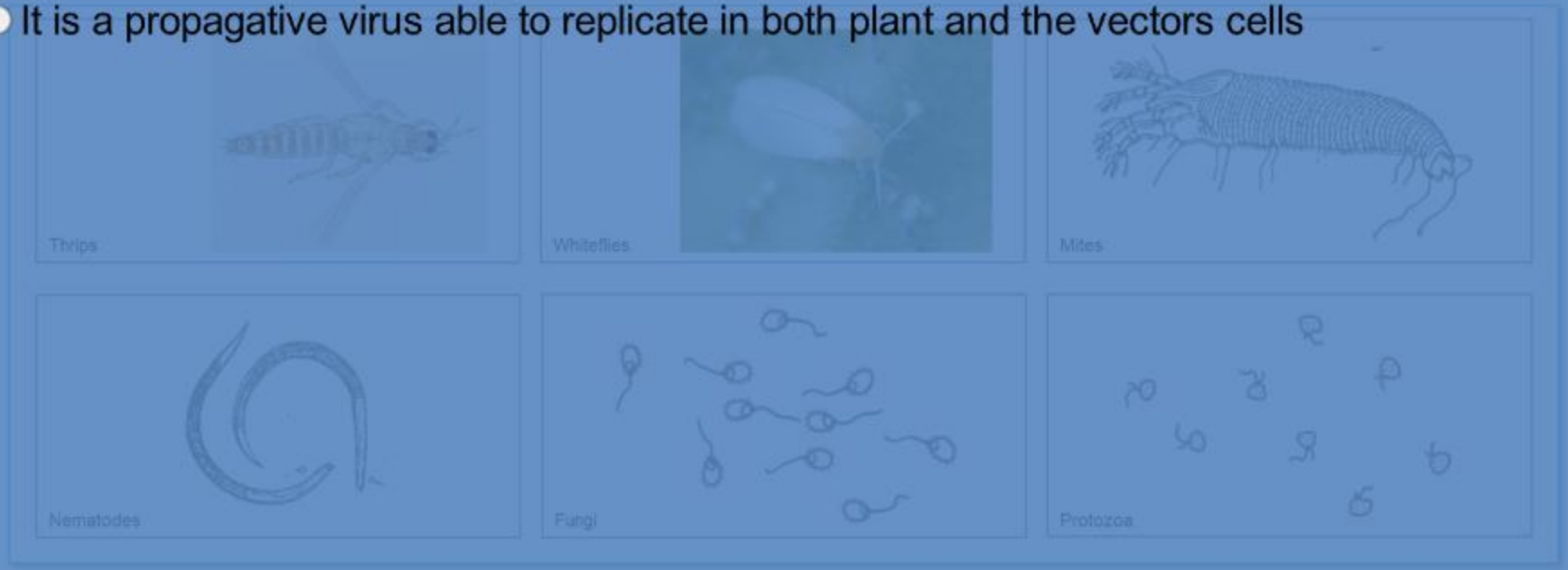
- It is a propagative virus able to replicate in both plant and the vectors cells



The positive-stranded RNAs of plant viruses are characterized by:

- Acting as messenger RNAs
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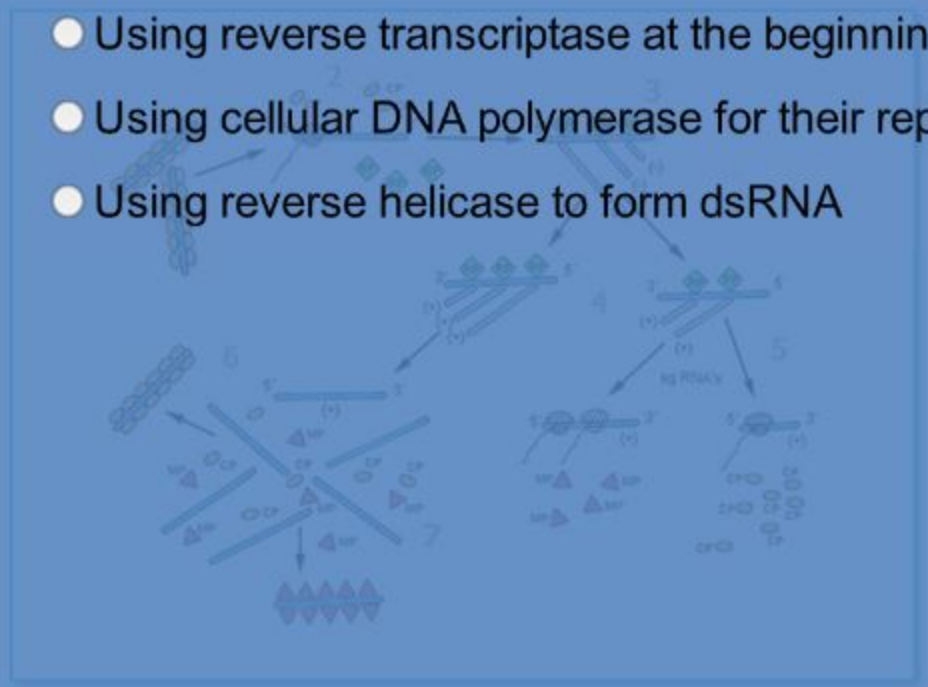

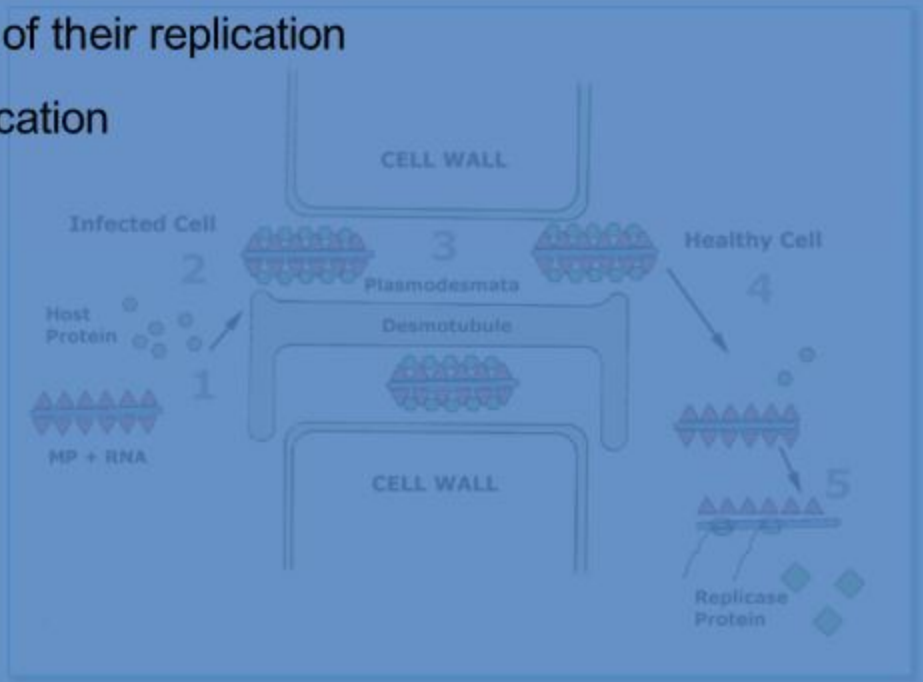

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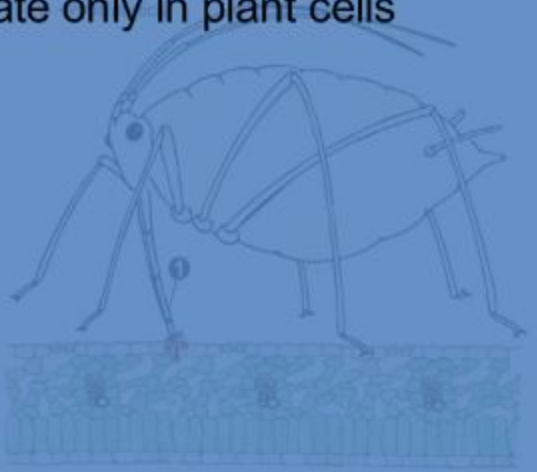
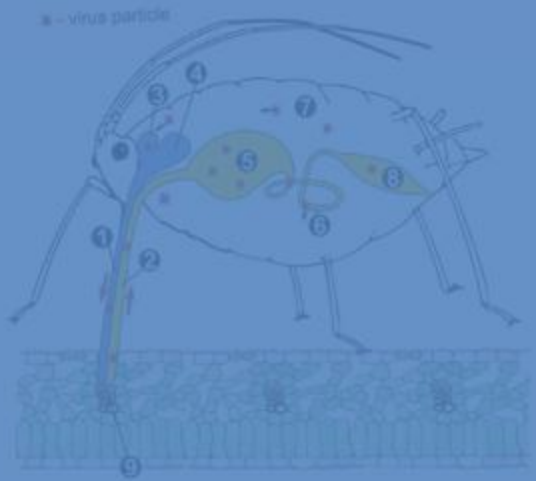


Reversible retention of virus particles at stylet tip. Protein HC (helper component) exists as an accessory factor for virus transmission



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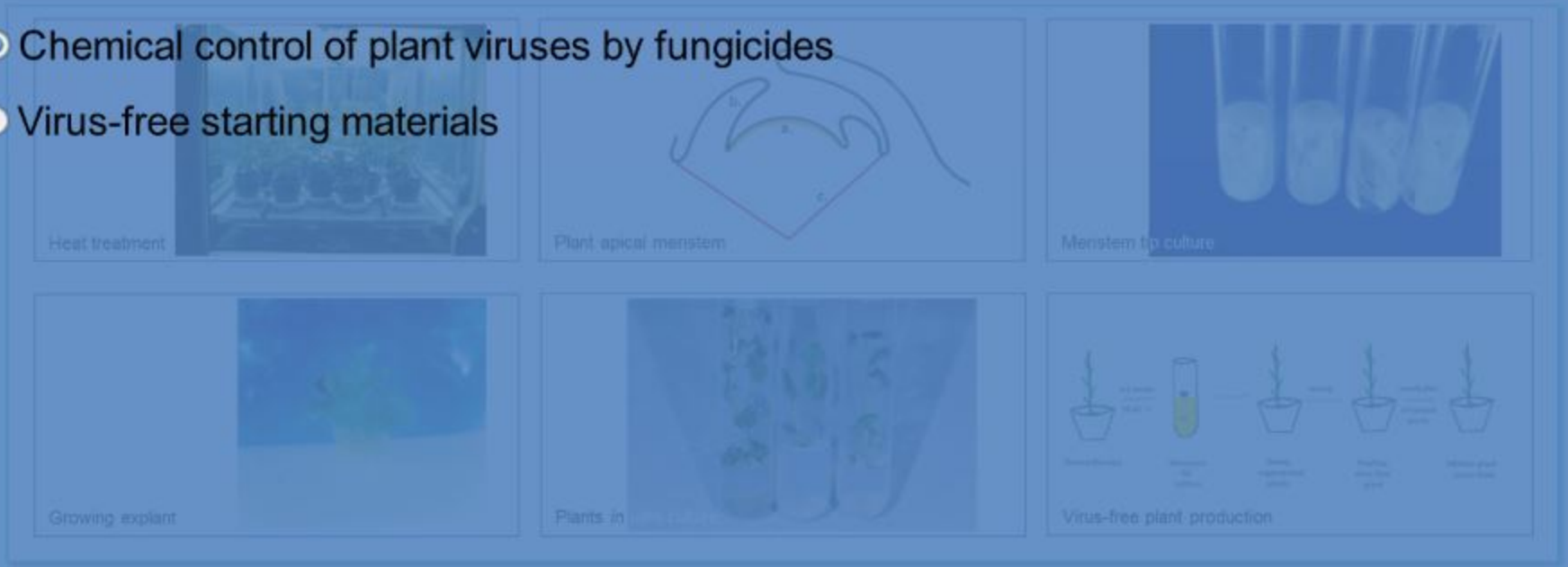

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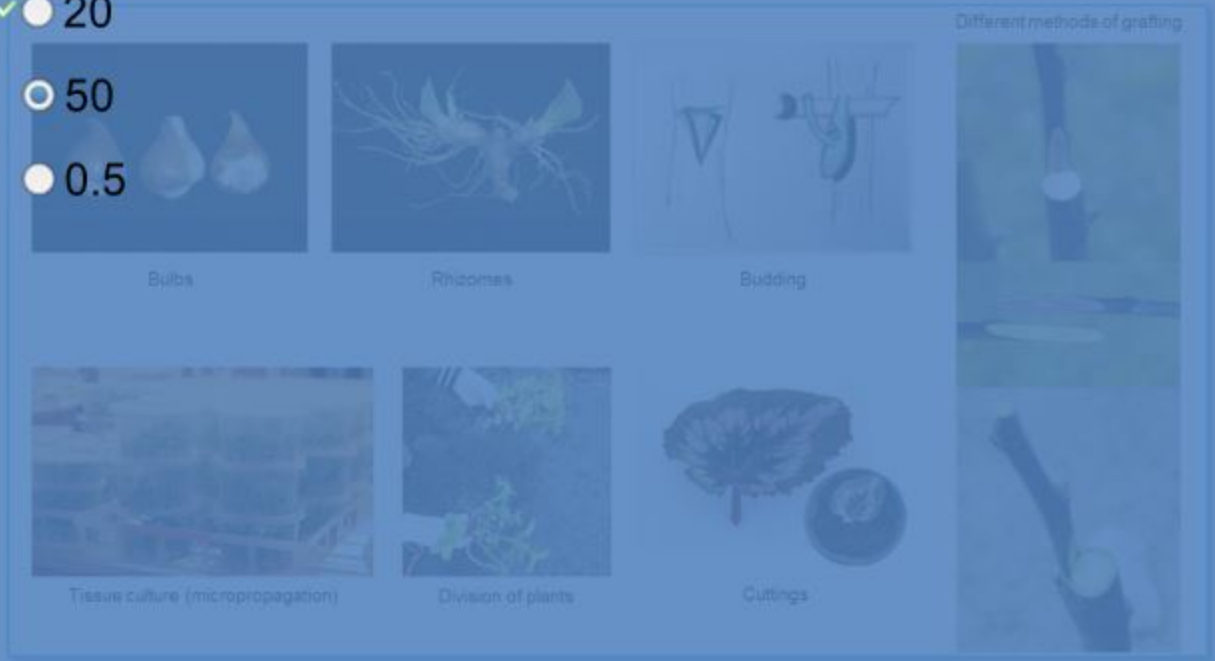

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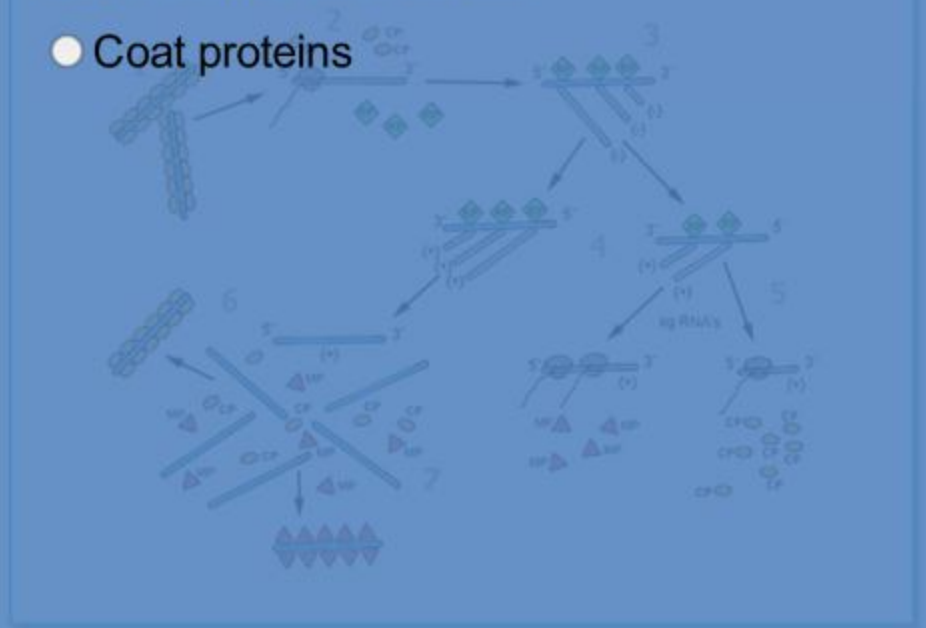

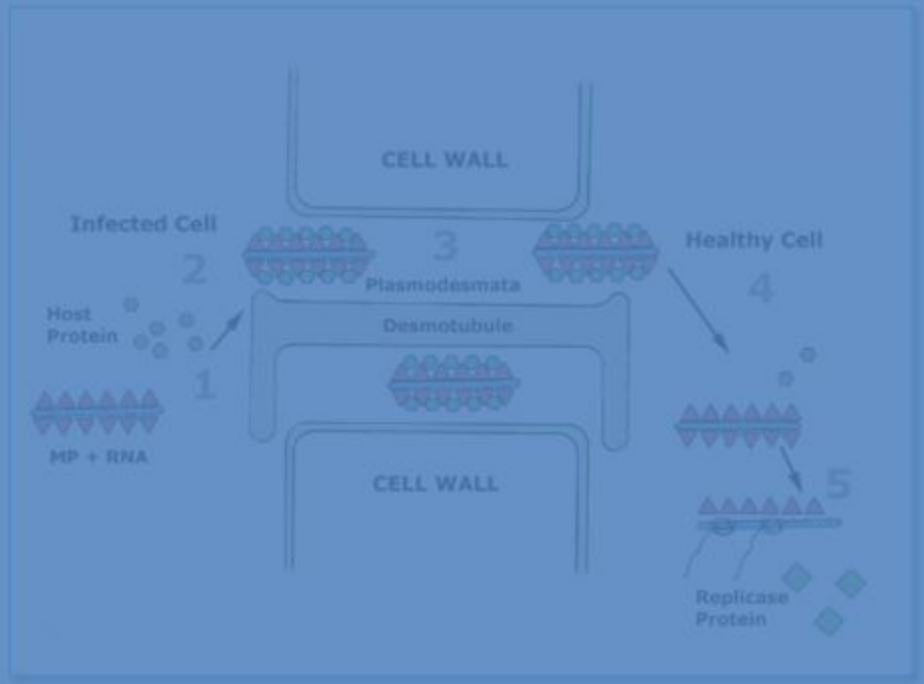

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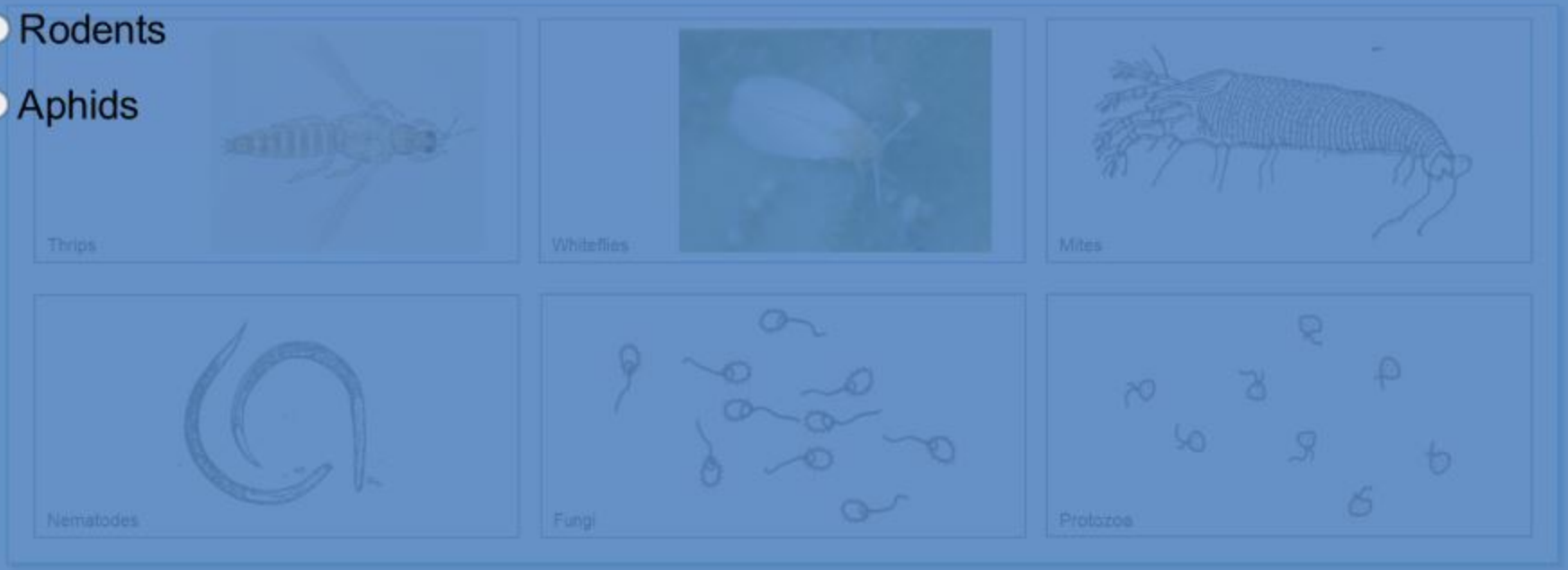

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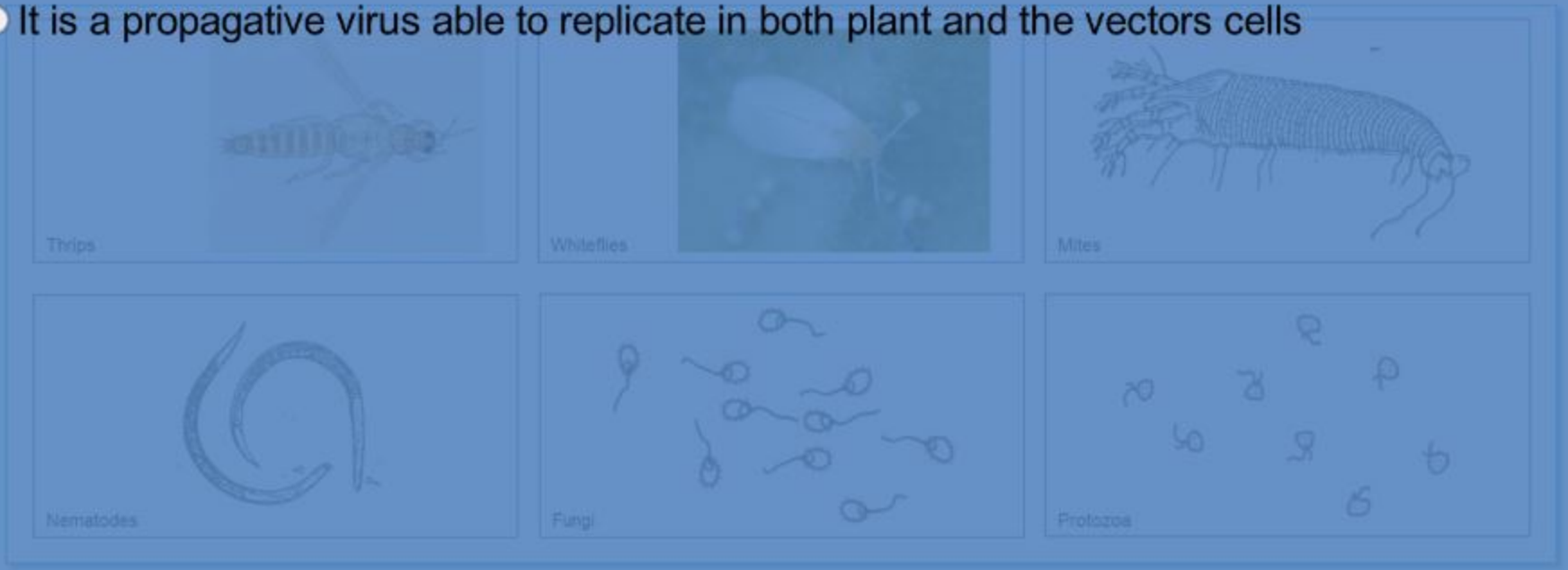

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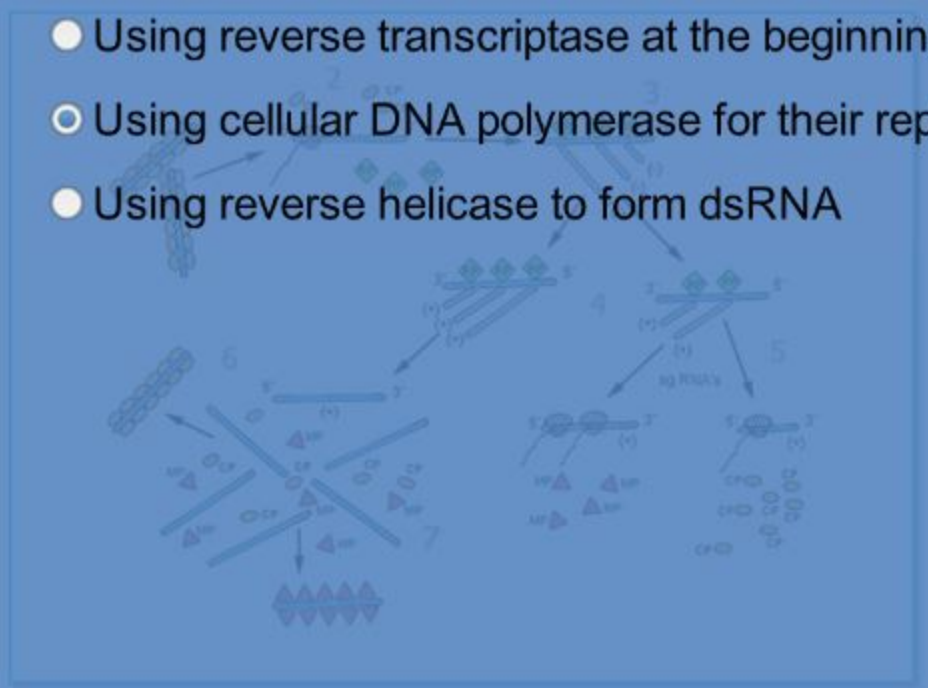

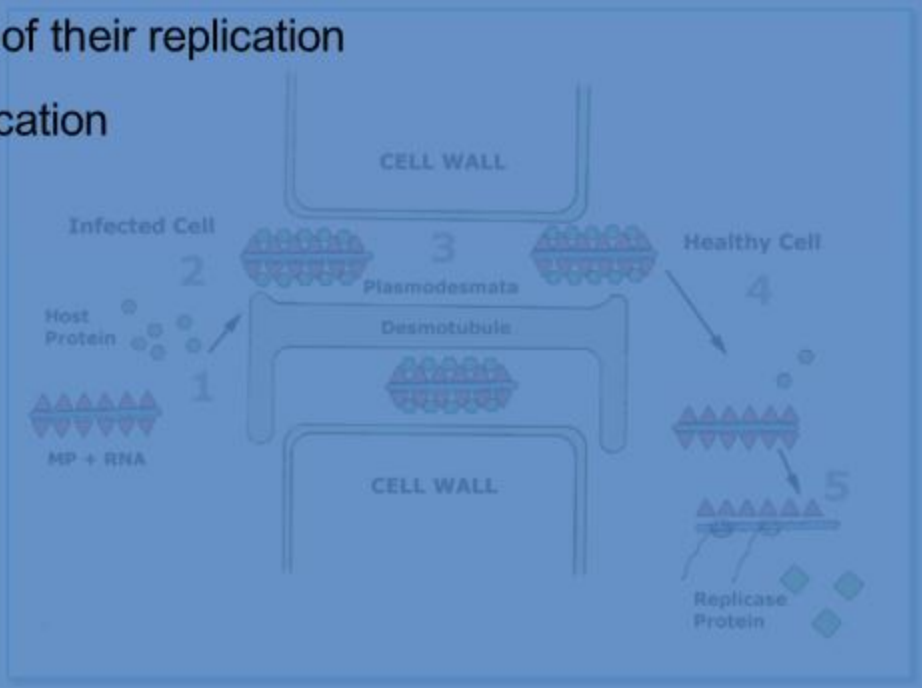

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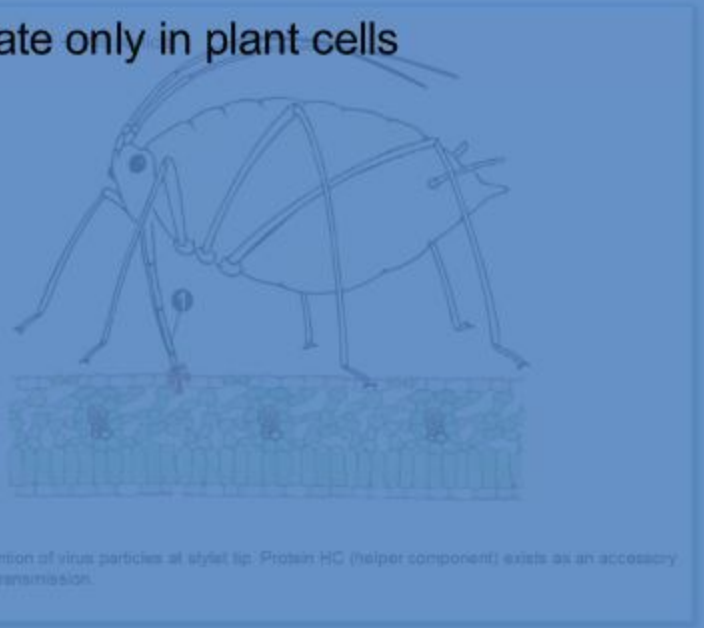

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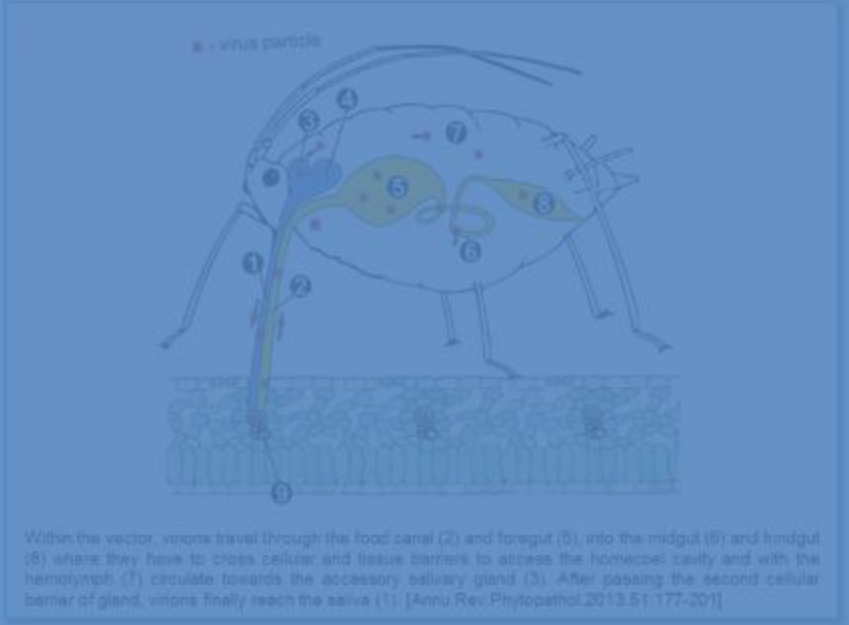

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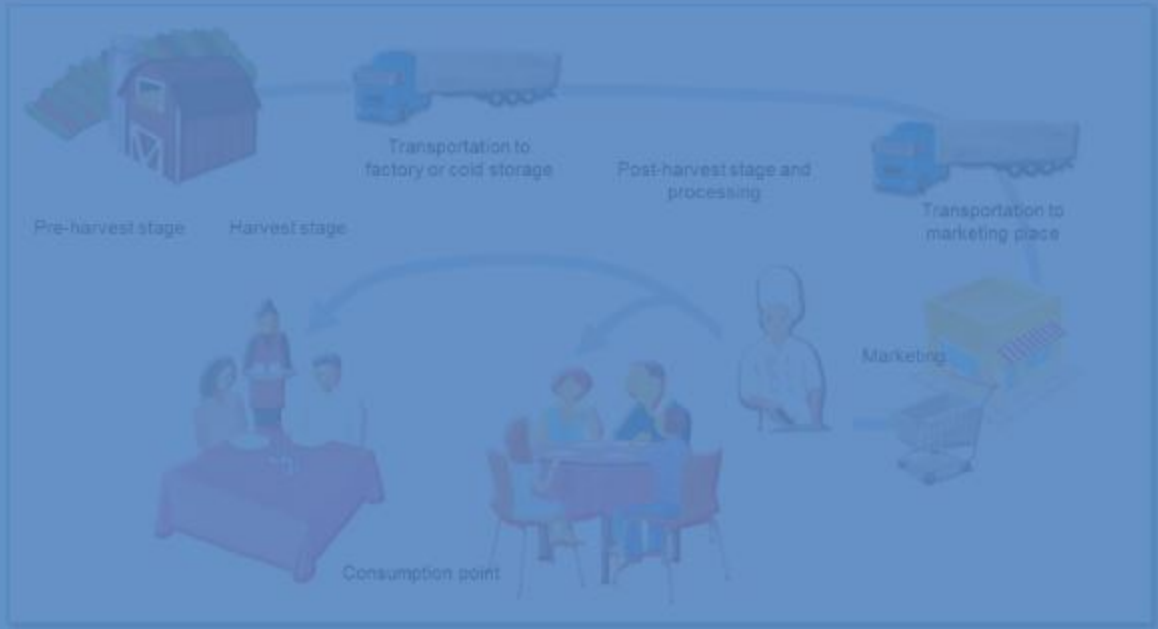
The hands of at least 14 people could be contaminated with viruses by touching a polluted door handle.

- True
- False



Foodborne viruses might develop resistance to high pressure processing.

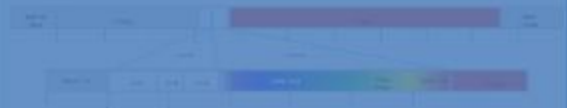
- False
- True

High hydrostatic pressure processing (HPP)

Photo of an industrial food high pressure processing unit ("Hiperbaric 420" by Hiperbaric)

Ultraviolet light (UV light)

Waves



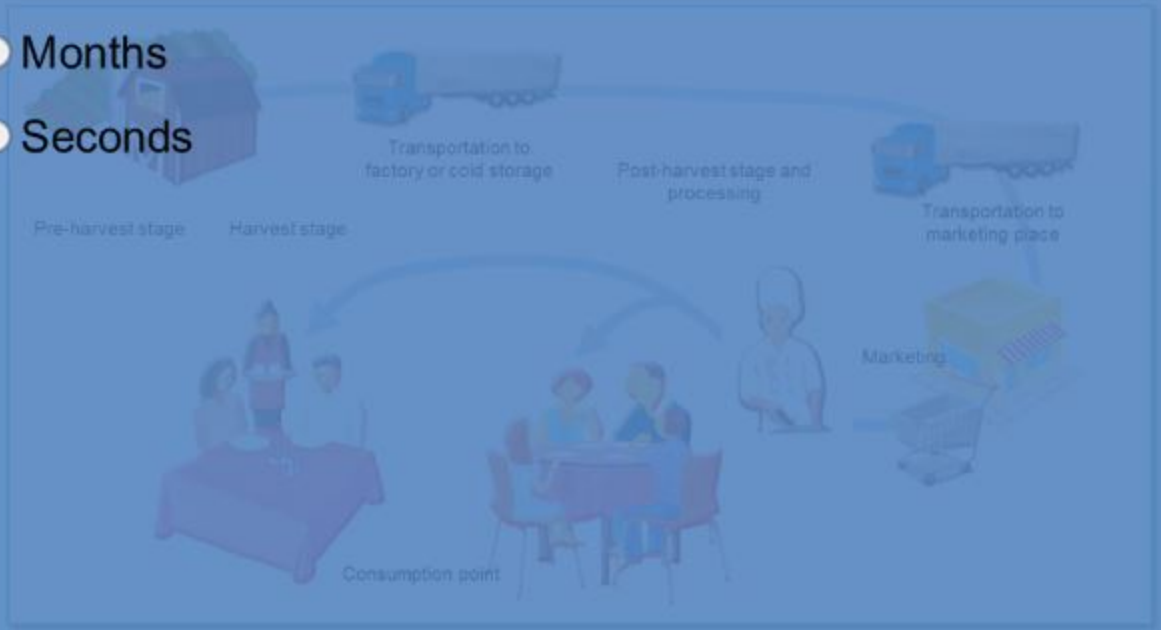
MICROBICIDAL REGION

Gamma irradiation

Special label required on irradiated foods - the international symbol of irradiation, known as a "radura".

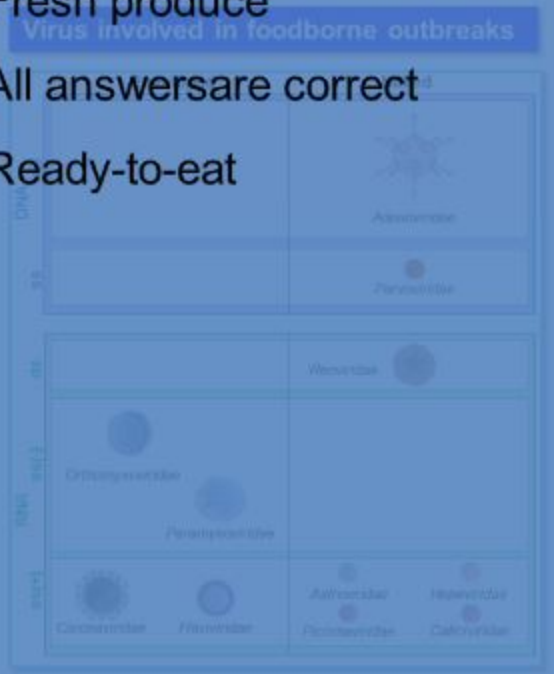
How long HAV maintains infectivity in manure and biosolids?

- Minutes
- Hours
- Months
- Seconds



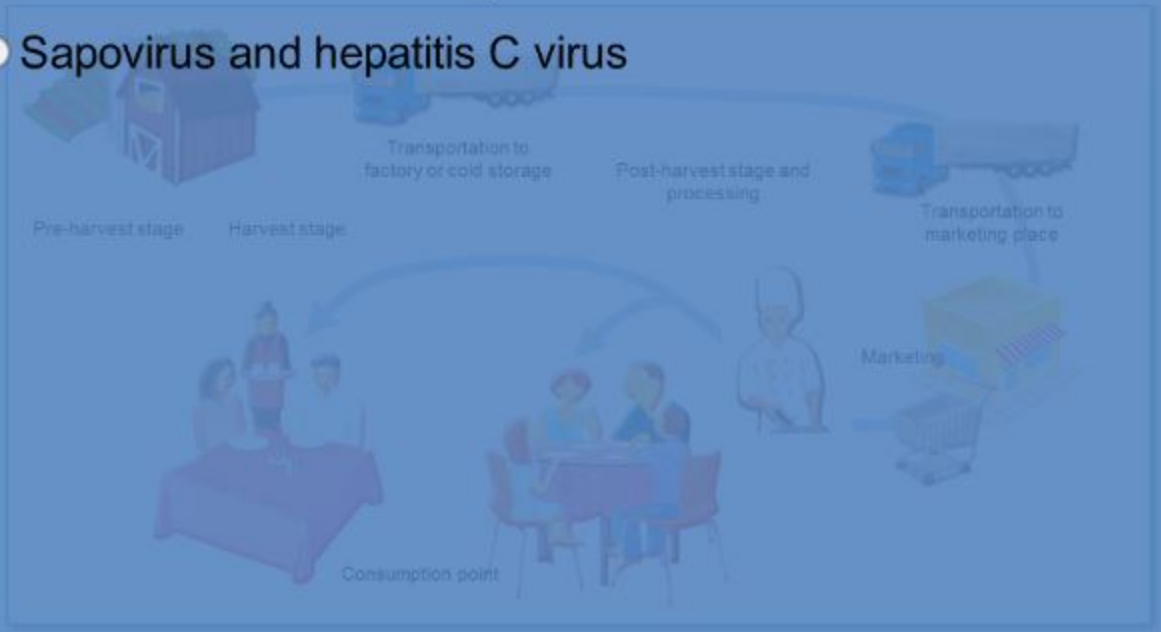
The food most frequently associated with foodborne viral outbreaks is

- Molluscan shellfish
- Fresh produce
- All answersare correct
- Ready-to-eat



Which of the foodborne viruses are of the greatest public health concern?

- Norovirus and hepatitis A virus
- Feline calicivirus and hepatitis B virus
- Sapovirus and hepatitis C virus



When preparing shellfish it is important that internal temperature reaches

- 82°C
- 76°C
- 90°C
- 70°C

High hydrostatic pressure processing (HPP)

Photo of an industrial food high pressure processing unit ("Hiperbaric 420" by Hiperbaric)

Ultraviolet light (UV light)

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Viruses multiply in food.

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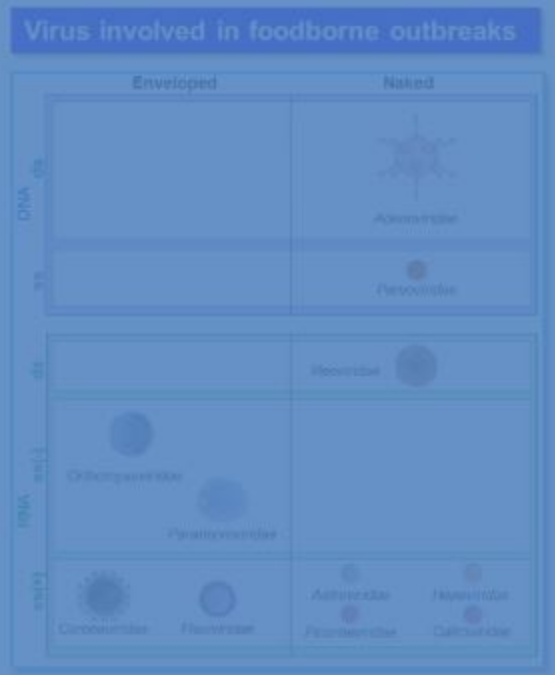

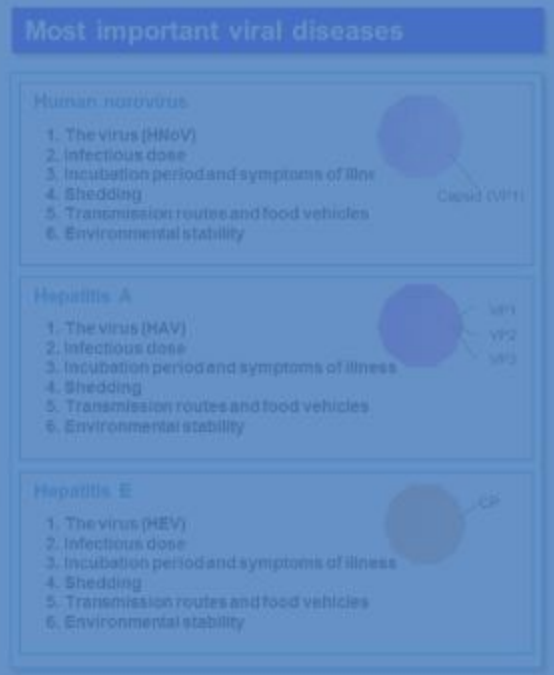

Which of hepatitis viruses is zoonotic?

- A
- B
- E
- C

Fill in the blank: Transmission of hepatitis_____ is usually by the fecal-oral route.

- D
- B
- A
- C

Pasteurization temperatures are sufficient to inactivate noroviruses.

- False
- True

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The hands of at least 14 people could be contaminated with viruses by touching a polluted door handle.

- [x] True
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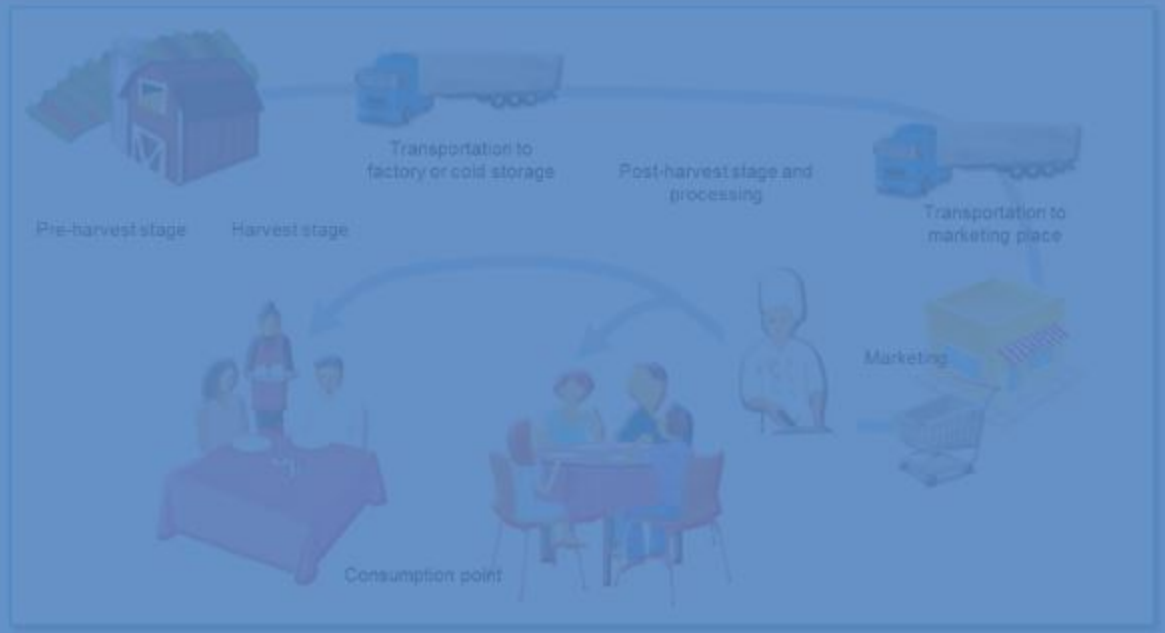

Foodborne viruses might develop resistance to high pressure processing.

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- ✓ True

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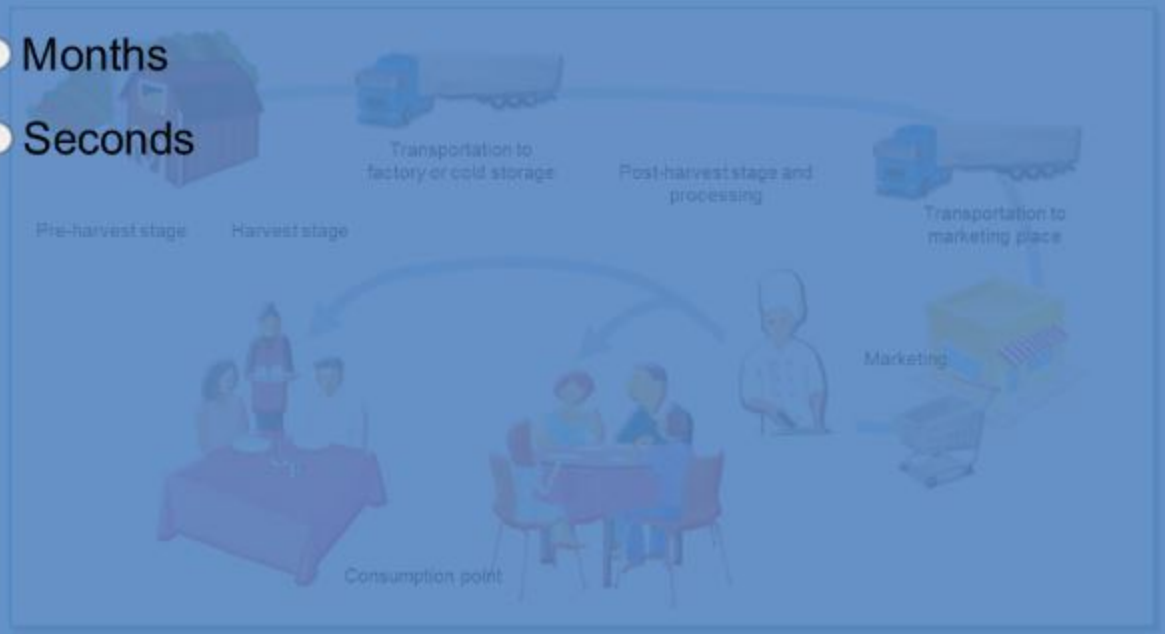

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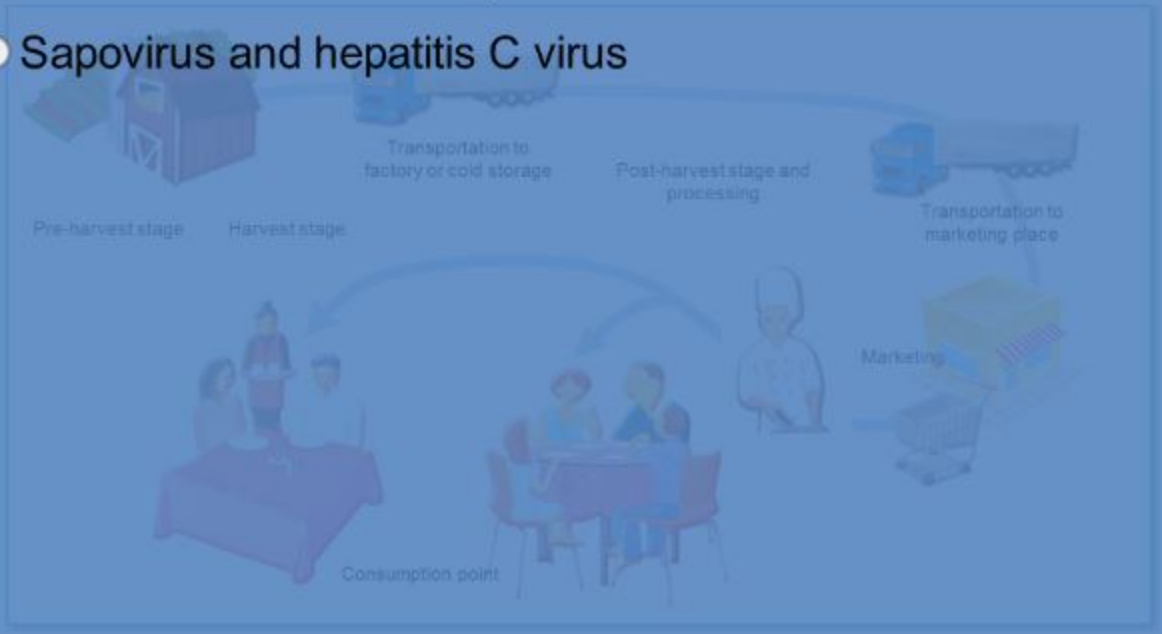

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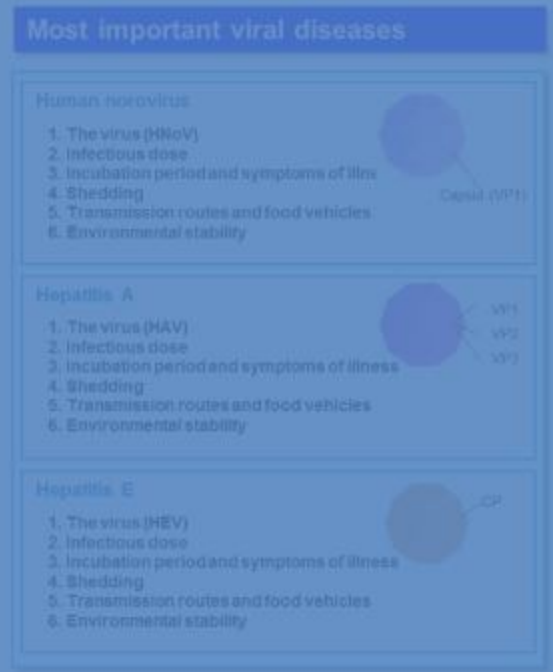

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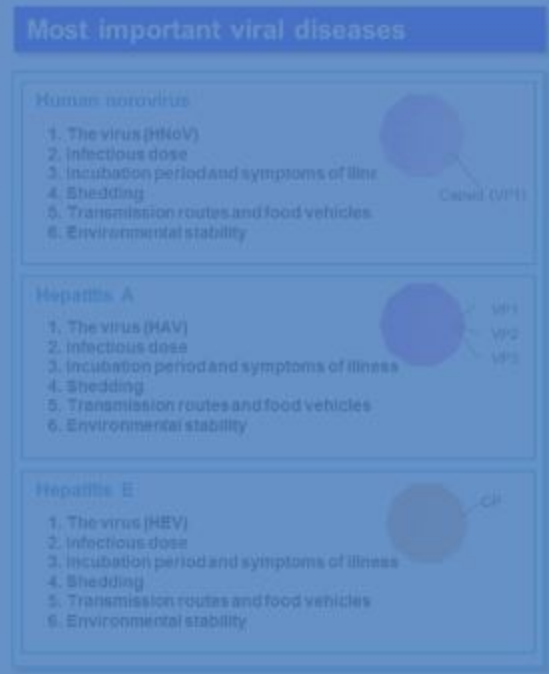

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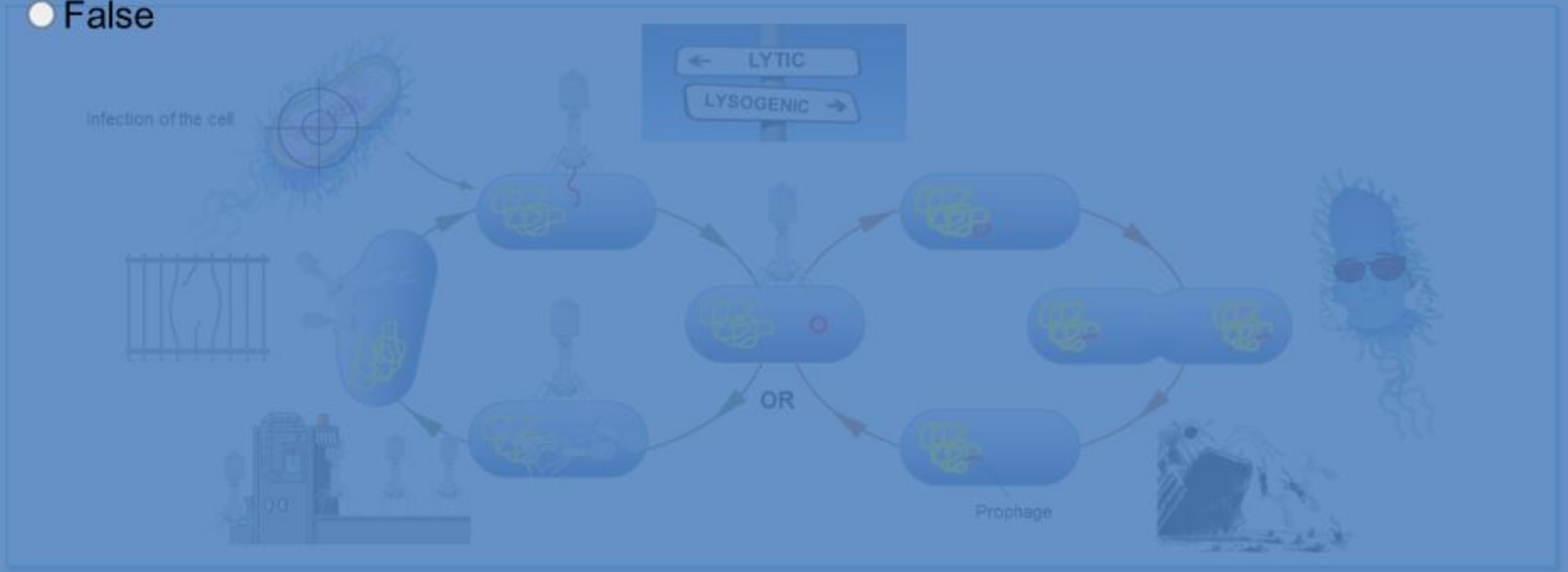

Archaeal viruses are principally classified based on their morphology

- True
- False

The family of Ampullaviridae groups bacterial viruses

- True
- False

The human gut has more bacterial cells than the total number of human cells

- True
- False

10,000,000,000,000,000,000,000,000,000,000,000 (10^{31}) phages are present on Earth.
It's estimated that 20-50% of all bacteria are killed by phages every day, keeping the bacterial numbers "in check".

Cheese production is dependent on lactic acid bacteria to ferment the milk. Phages that kill these fermentor culture bacteria cause significant losses in cheese production.

Bacteriophage-derived enzymes called endolysins can be used to kill bacteria

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Archaeal viruses can be found in acidic lakes

- True
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Prophages can endow beneficial properties to/for the bacterial host

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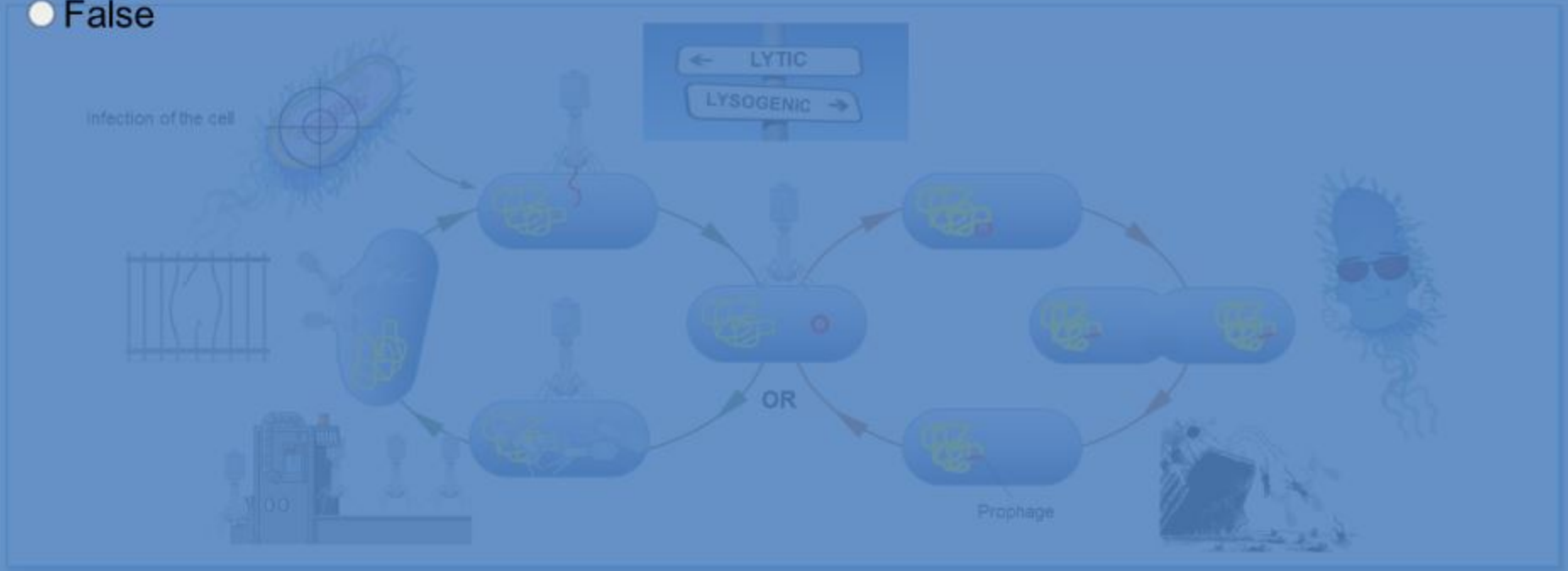
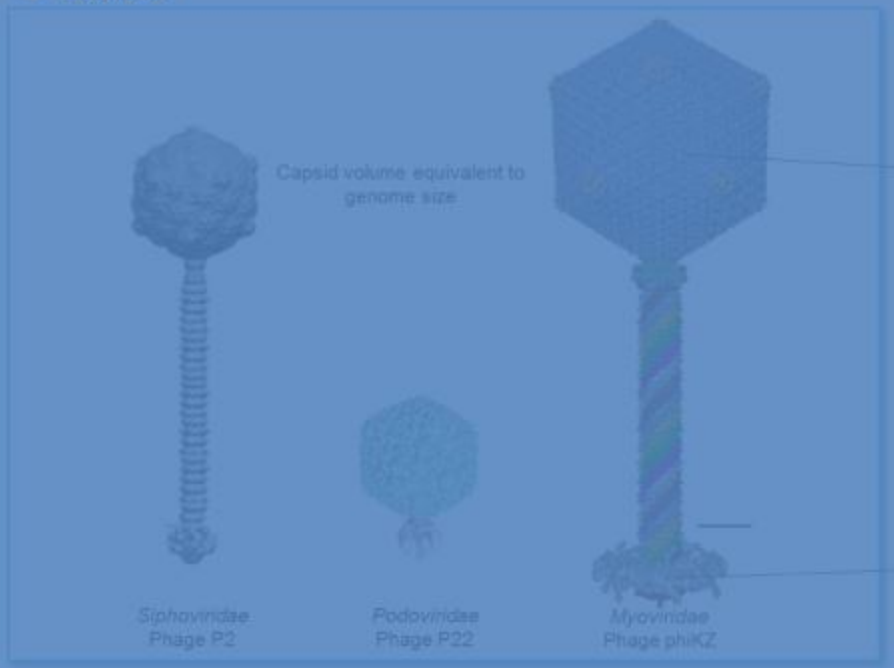
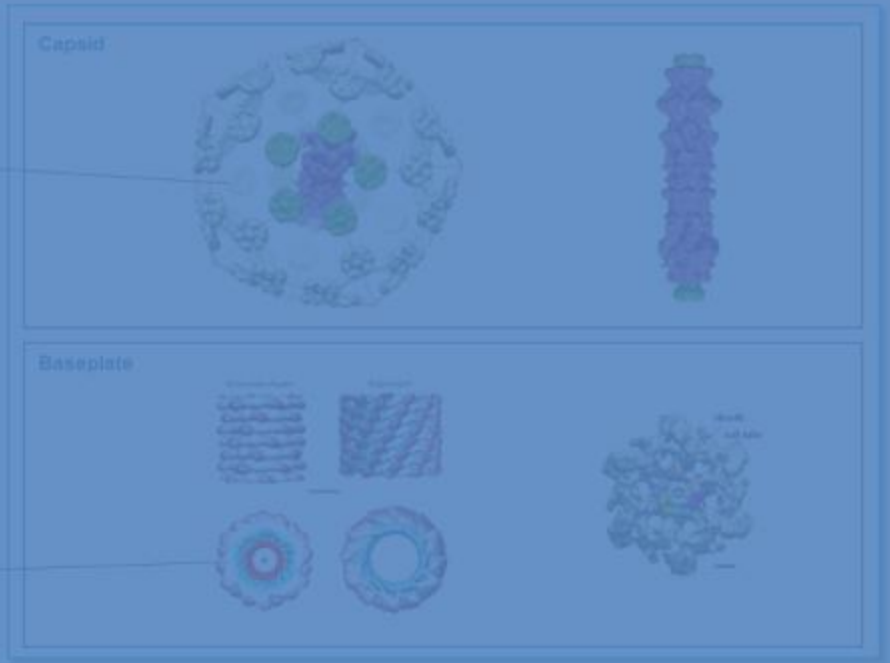


Siphoviridae members include bacterial viruses with a long-contractile tail

- True
- False





In tailed phages, the tail fibers propel the virus in water

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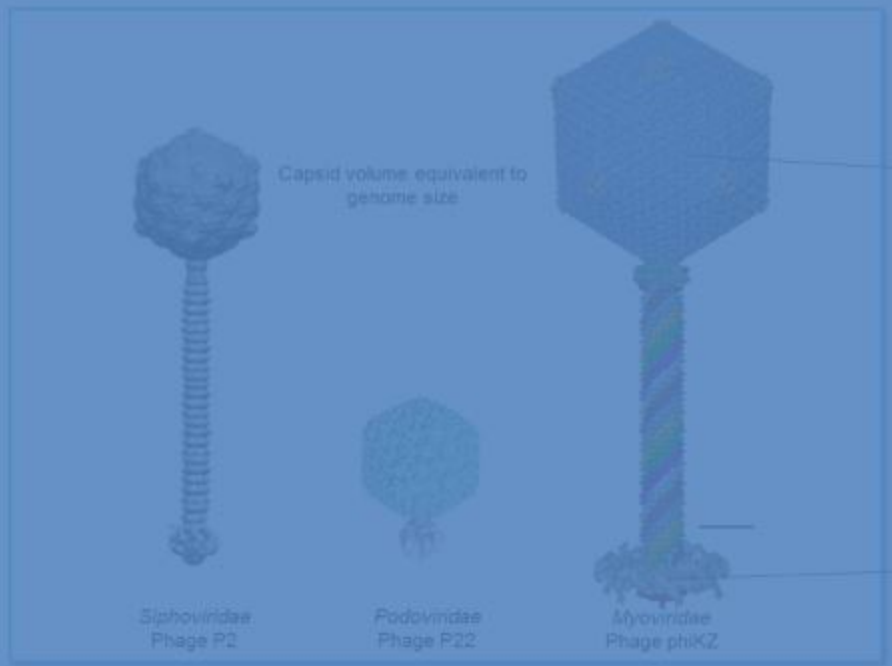

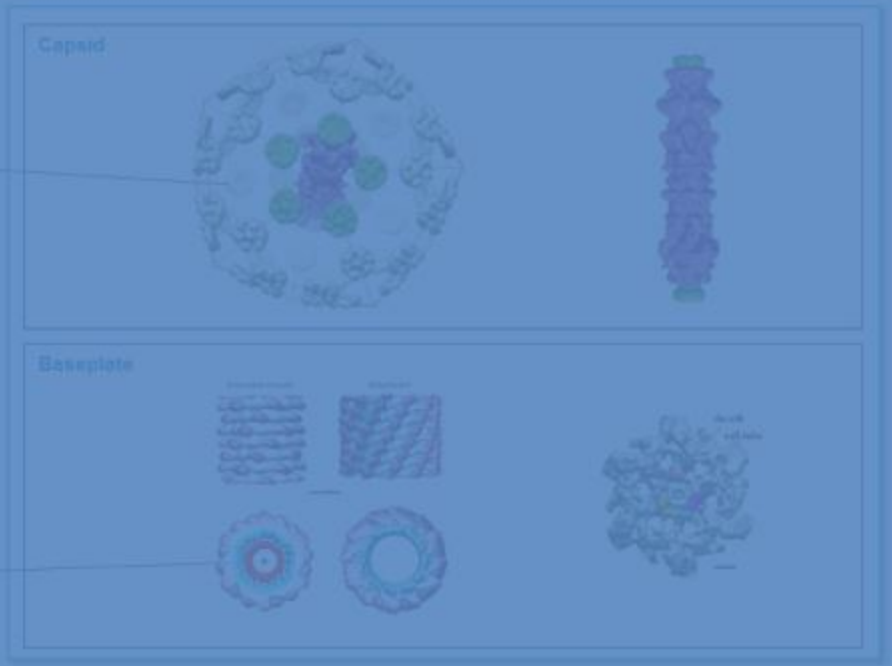

The principal components of bacterial virus particles include DNA and proteins

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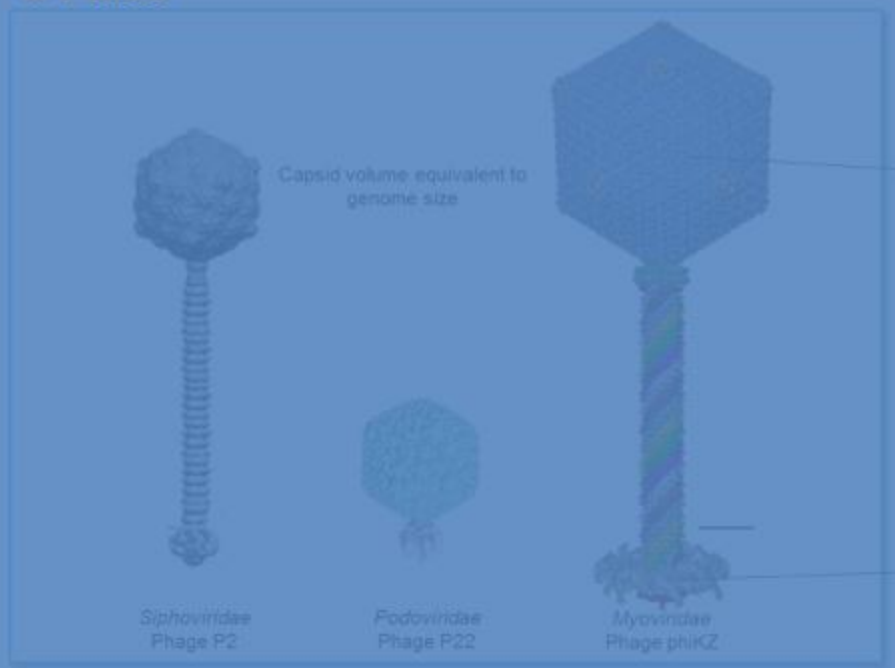

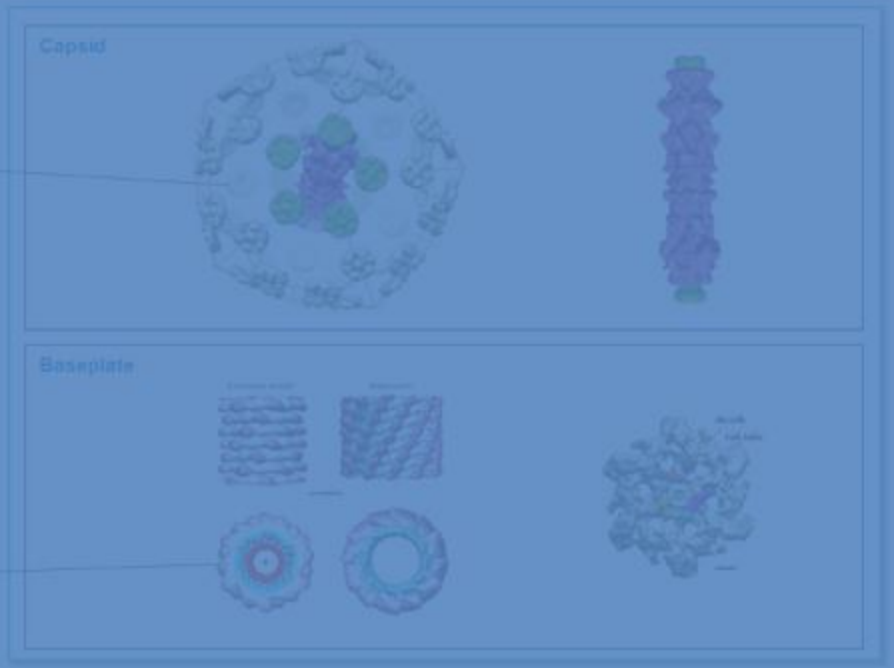

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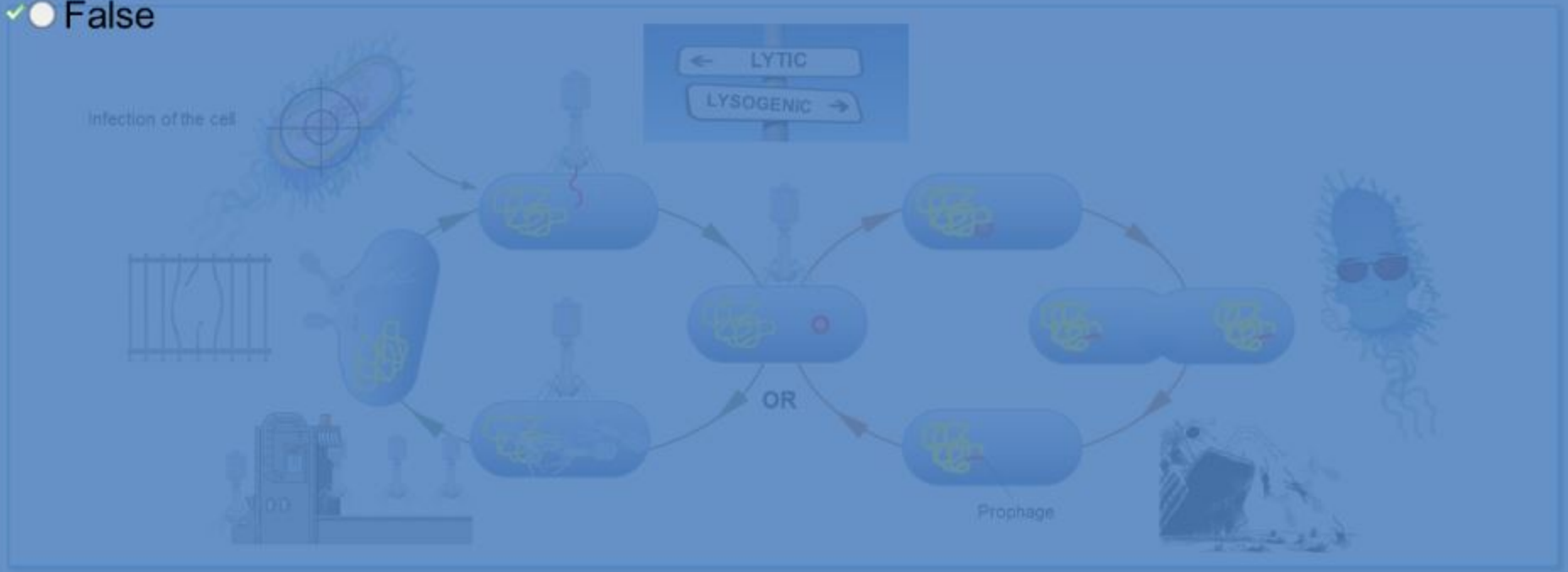

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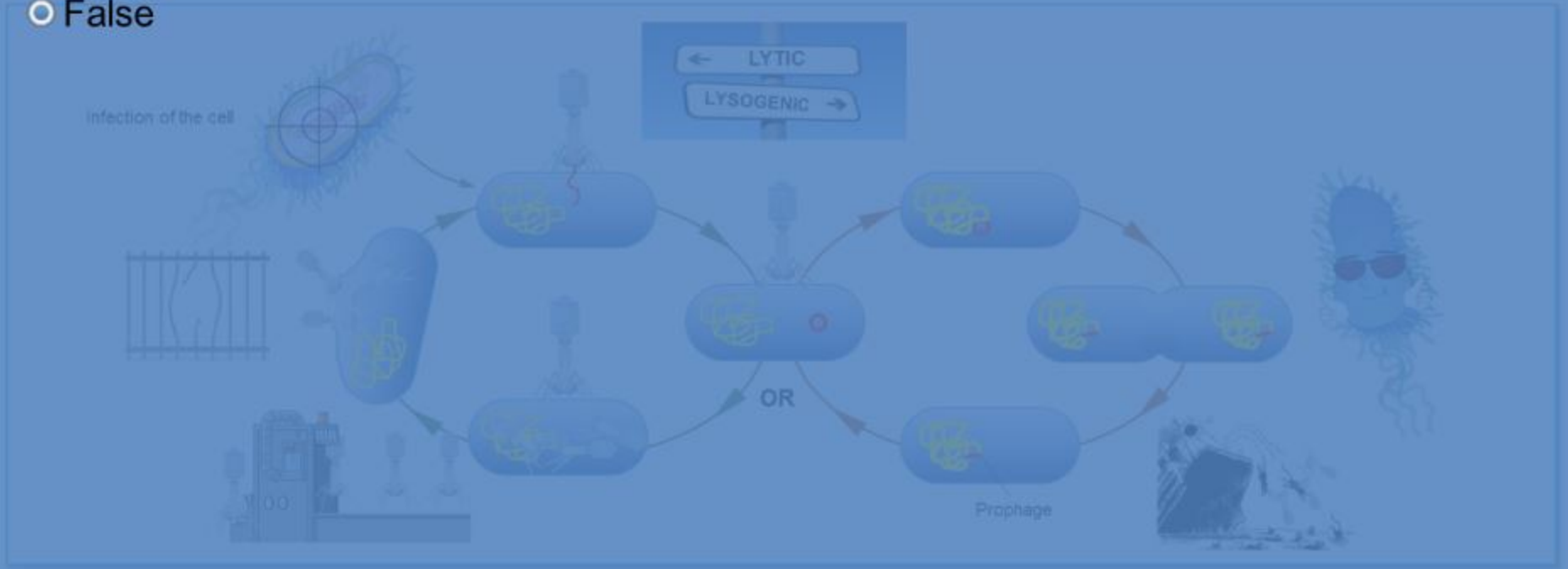

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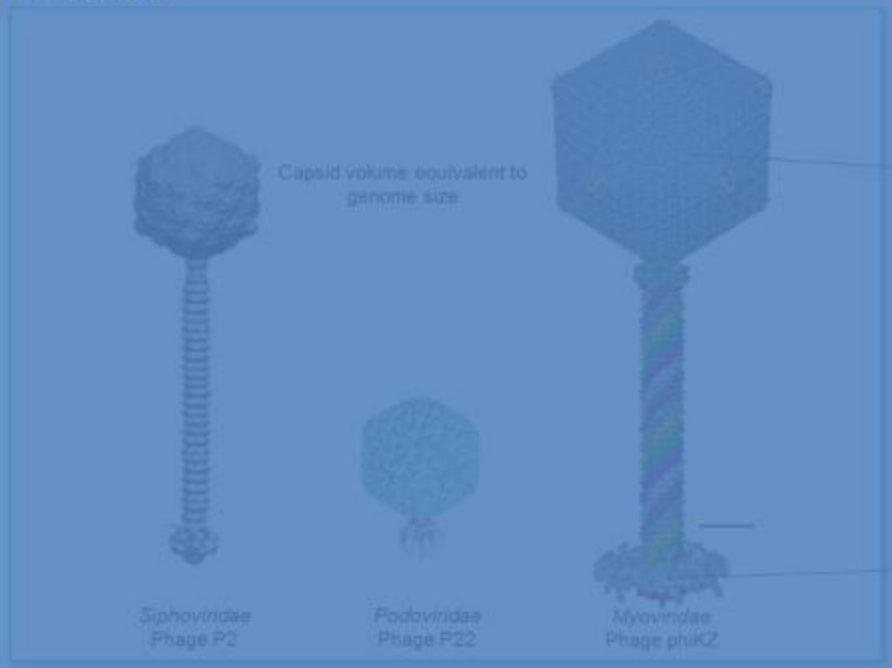

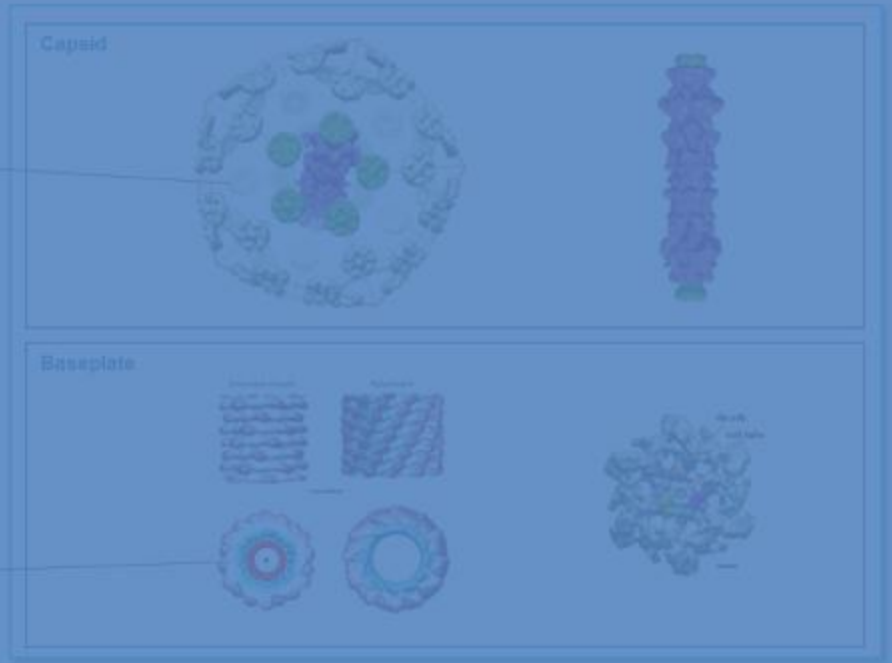

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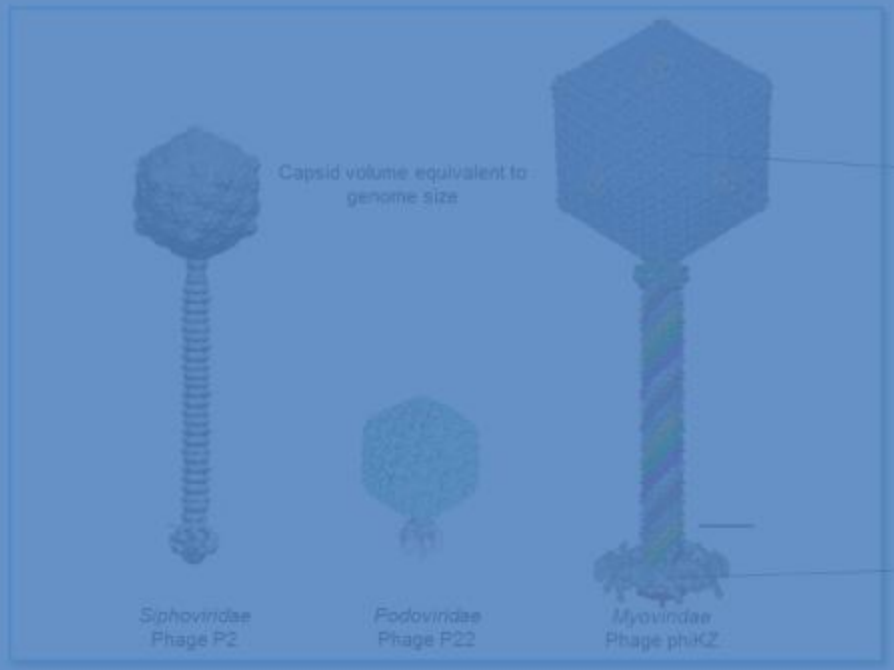

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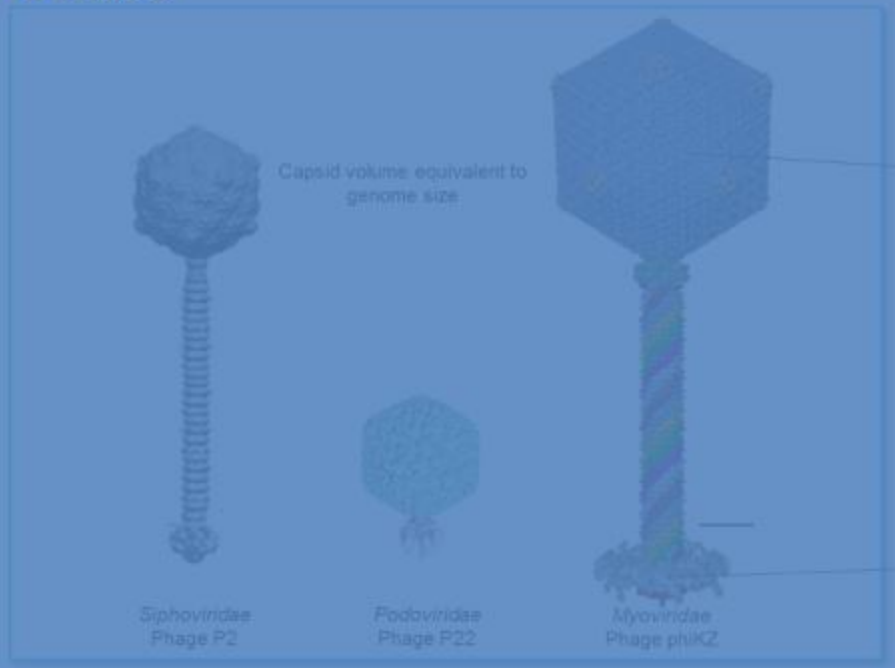

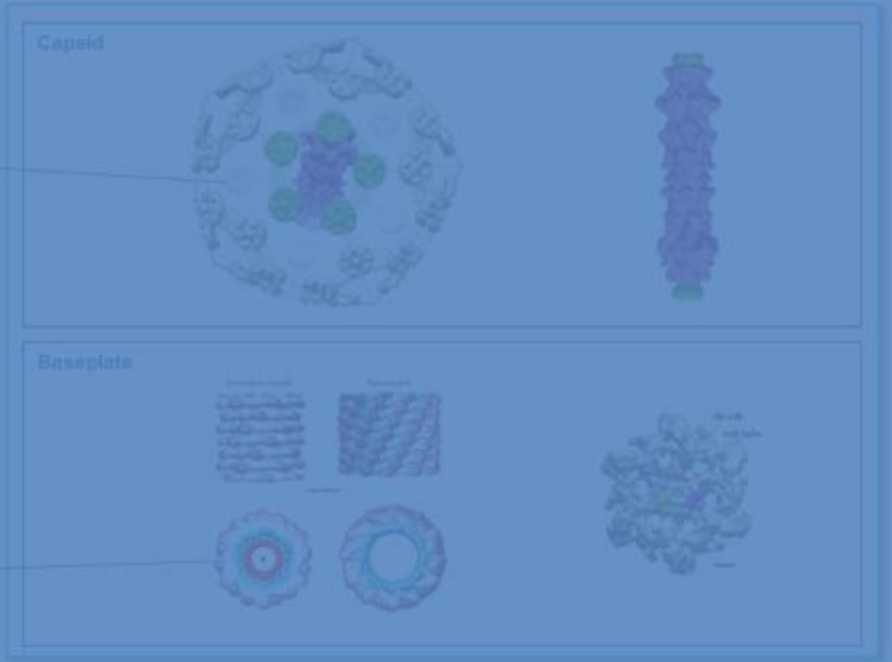

Phages can be engineered as biological batteries

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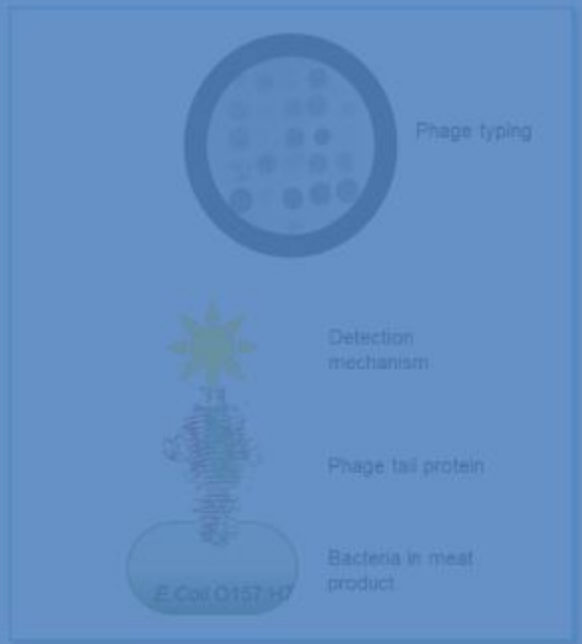

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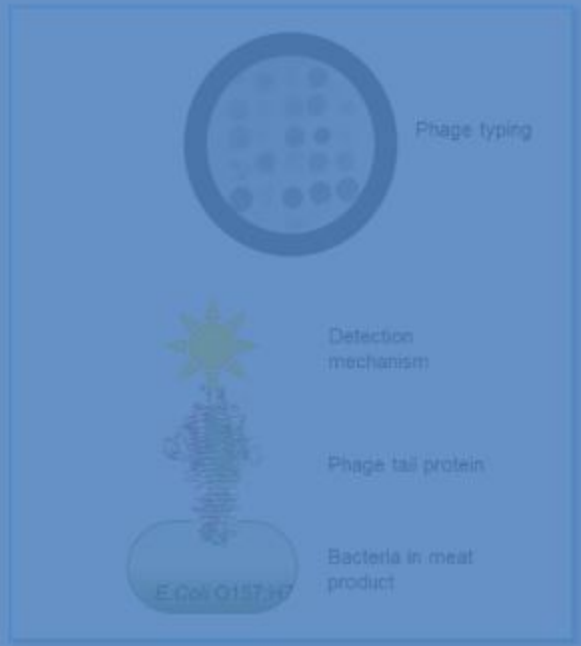

A viral vector system always gives a strong expression of a foreign gene

- True
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Phage experiments proved proteins encode the hereditary traits

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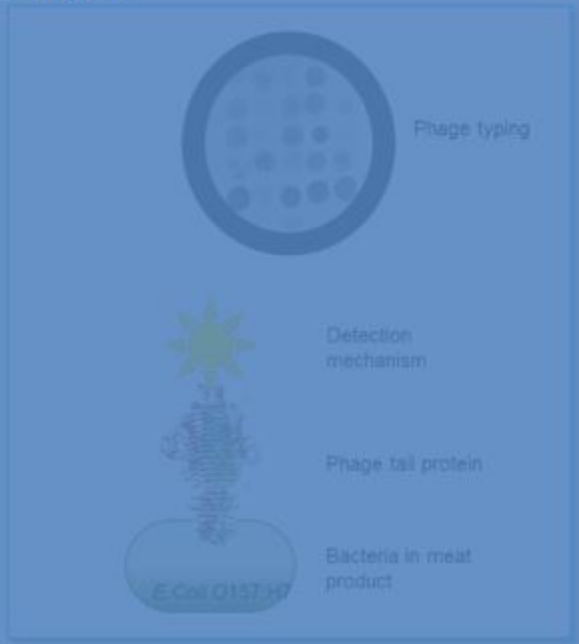

The ethical debate of creating genetically modified organisms (GMOs) using viruses has been settled forever

- True
- False

Adenoviruses can be used to transfer foreign genes into eukaryotic cells

- True
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Transduction is a DNA transfer mechanism based on virus infection

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Phage display is a lab technique to expose proteins on the surface of bacterial viruses

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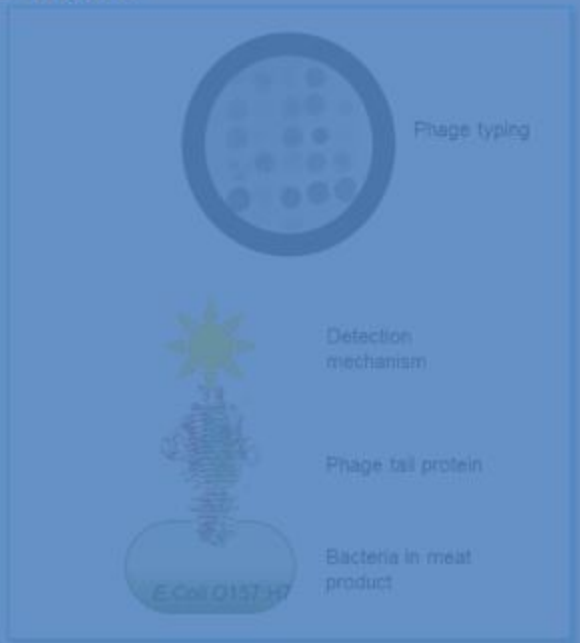

Tail proteins from bacterial viruses are highly specific in recognizing bacteria

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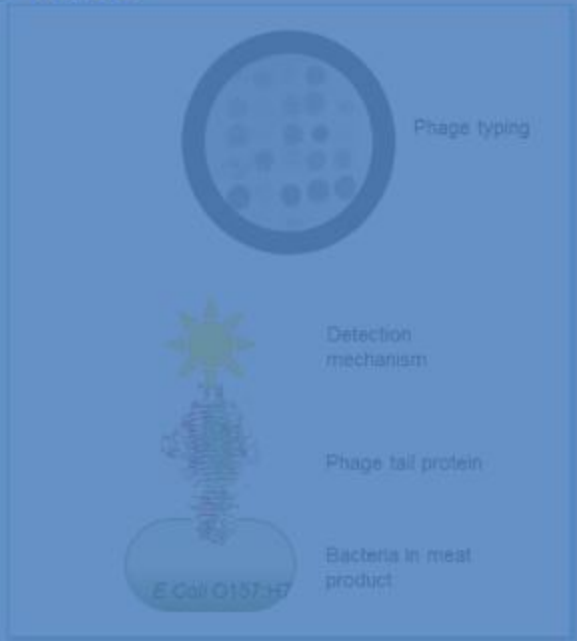

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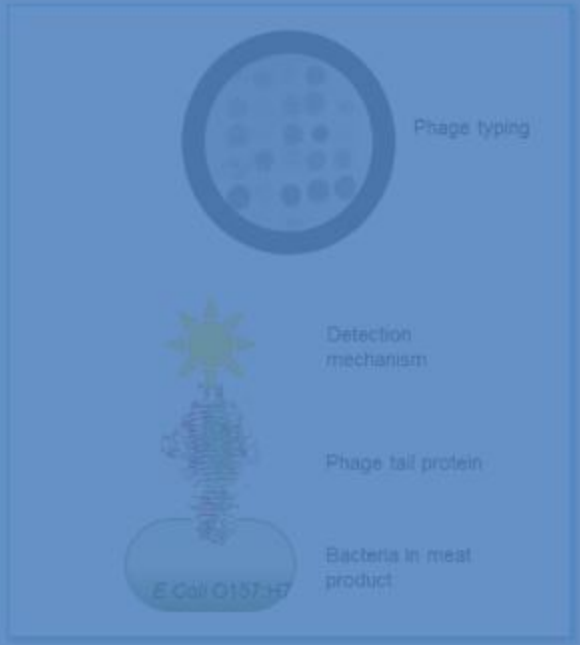

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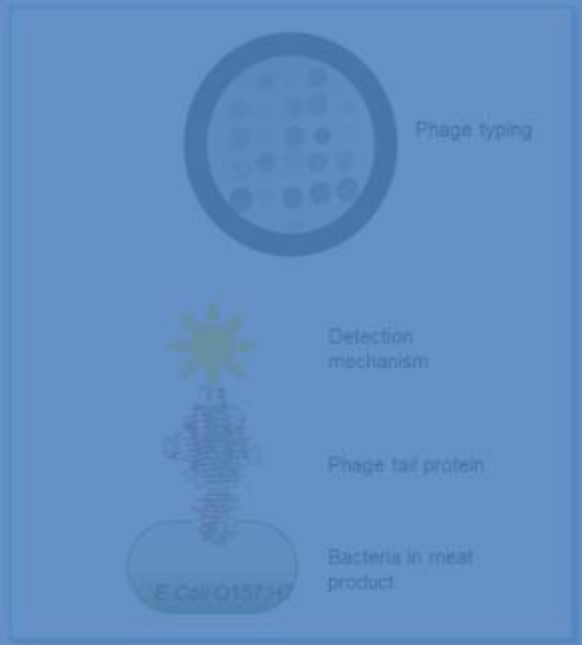

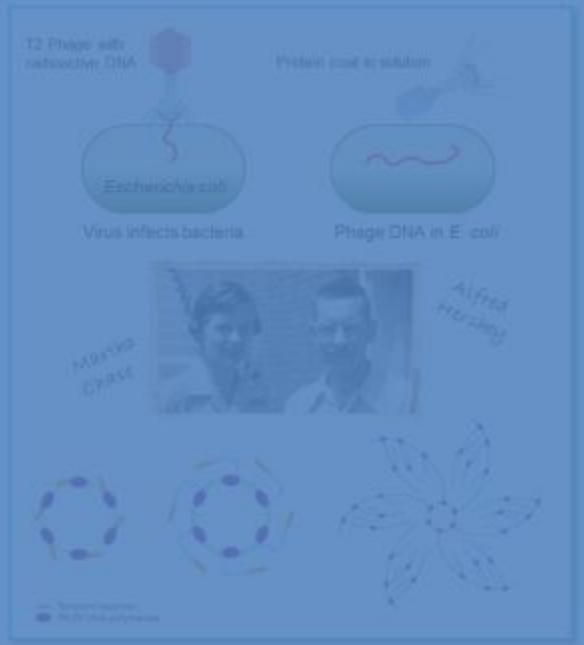

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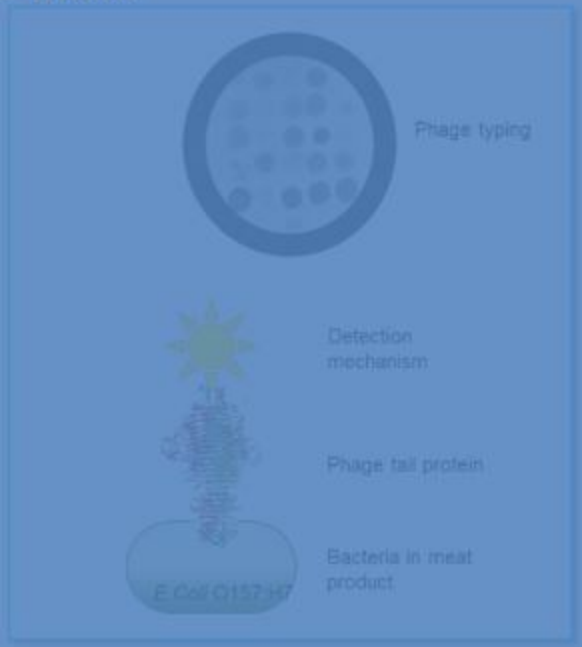

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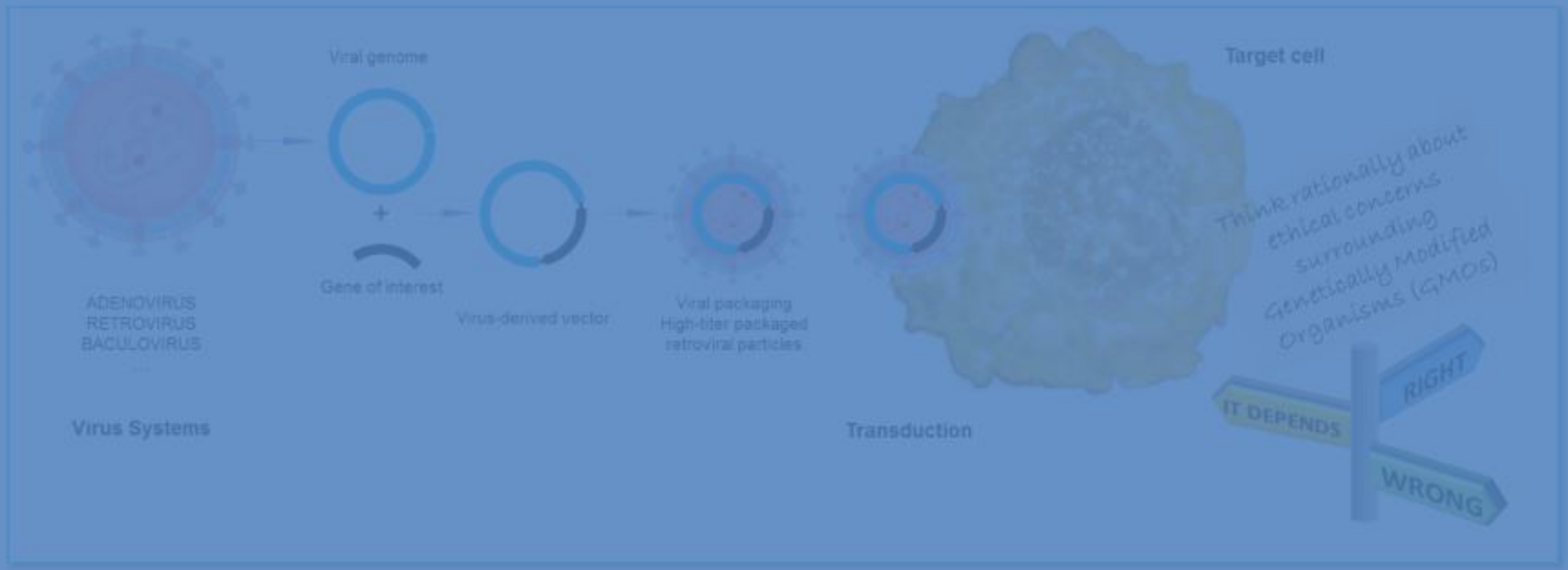

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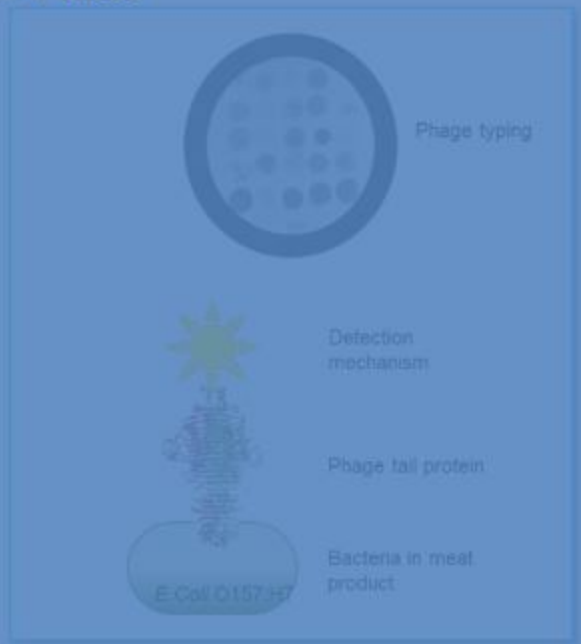

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